

TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371

FORSAL-27

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

10/009095

INTERNATIONAL APPLICATION NO. INTERNATIONAL FILING DATE PRIORITY DATE CLAIMED
PCT/FI00/00410 09 May 2000 (9.05.00) 10 May 1999 (10.05.99)TITLE OF INVENTION Method and Arrangement of Impingement for Blowing Compensation of a
Tendency of Curling of a Paper Board Web to be Treated as well as a Paper or Board Machine
APPLICANT(S) FORDO/EO/US ; AHONEN, Pasi; KIISKINEN, Harri and TIMOFEEV, Oleg

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. is attached hereto (required only if not communicated by the International Bureau).
 - b. has been communicated by the International Bureau.
 - c. is not required, as the application was filed in the United States Receiving Office (RO/US).
6. An English language translation of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. is attached hereto.
 - b. has been previously submitted under 35 U.S.C. 154(d)(4).
7. Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
 - a. are attached hereto (required only if not communicated by the International Bureau).
 - b. have been communicated by the International Bureau.
 - c. have not been made; however, the time limit for making such amendments has NOT expired.
 - d. have not been made and will not be made.
8. An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. A **FIRST** preliminary amendment.
14. A **SECOND** or **SUBSEQUENT** preliminary amendment.
15. A substitute specification.
16. A change of power of attorney and/or address letter.
17. A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. Other items or information:

Clean Copy of Substitute Specification under 37 U.S.C. 1.125(c)

Marked Up Copy of Substitute Specification under 37 C.F.R. 1.125(b)(2)

Statement as to Lack of New Matter under 37 C.F.R. 1.125(b)(1)

U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 10/009095	INTERNATIONAL APPLICATION NO PCT/FI00/00410	ATTORNEY'S DOCKET NUMBER FORSAL-27		
21. <input checked="" type="checkbox"/> The following fees are submitted:		CALCULATIONS PTO USE ONLY		
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):				
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO.		\$1040.00		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO		\$890.00		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO		\$740.00		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)		\$710.00		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)		\$100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =		\$ 1,040.00		
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).		\$		
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	\$
Total claims	39 - 20 =	19	x \$18.00	\$ 342.00
Independent claims	4 - 3 =	1	x \$84.00	\$ 84.00
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$280.00	\$ 0.00
TOTAL OF ABOVE CALCULATIONS =		\$ 1,466.00		
<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.		+	\$ 0.00	
SUBTOTAL =		\$ 1,466.00		
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).		\$		
TOTAL NATIONAL FEE =		\$ 1,466.00		
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property		+	\$ 0.00	
TOTAL FEES ENCLOSED =		\$ 1,466.00		
		Amount to be refunded:	\$	
		charged:	\$	
<p>a. <input checked="" type="checkbox"/> A check in the amount of \$ 1,466.00 to cover the above fees is enclosed.</p> <p>b. <input type="checkbox"/> Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.</p> <p>c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. <u>15-0660</u>. A duplicate copy of this sheet is enclosed.</p> <p>d. <input type="checkbox"/> Fees are to be charged to a credit card. WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.</p>				
<p>NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.</p>				
SEND ALL CORRESPONDENCE TO:				
<p>David R.J. Stiennon Lathrop & Clark LLP 740 Regent Street, Suite 400 P.O. Box 1507 Madison, WI 53701-1507 USA</p>				
<p><u>David R.J. Stiennon</u> SIGNATURE</p>				
<p>_____ <u>David R.J. Stiennon</u> NAME</p>				
<p>_____ <u>33212</u> REGISTRATION NUMBER</p>				

Rec'd PCT/PTO 13 MAR 2002
10/009095

In The United States Patent And Trademark Office

Applicant: Pasi Ahonen, et al.

Date: November 8, 2001

Date Filed: Simultaneously herewith

Docket No.: FORSAL-27

PCT App. No.: PCT/FI00/00410

For: Method and Arrangement of Impingement for Blowing Compensation of a Tendency of Curling of a Paper Board Web to be Treated as Well as a Paper or Board Machine

Certificate of Express Mailing

I hereby certify that this document is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 35 C.F.R. §1.10
on 8 November 2001

with Mailing Label No. EVO15 203 645 US
and is addressed to the Assistant Commissioner for Patents,
Washington, D.C. 20231.

David R. J. Stiennon

Signature

David R. J. Stiennon, Reg. No. 33212
Name of applicant, assignee or Registered Representative

Preliminary Amendment

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

Prior to examination of the above application, please amend the application as follows.

In the Specification:

Please amend the specification as shown on the accompanying Clean Copy of Substitute Specification. A Marked Up Copy of Substitute Specification is also provided, as well as a Statement as to Lack of New Matter under 37 C.F.R. 1.125(b)(1).

In the Claims:

Please cancel claims 1-33.

Please add the following new claims:

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

34. An air impingement arrangement for compensating for the curling tendency of a paper or board web which is being treated, which air impingement arrangement is disposed in connection with a paper or board process or with a related finishing process and extends substantially across the entire width of the web running in the vicinity thereof and forms a contact-free web treatment zone, in which paper, board and/or finishing process the web is dried in at least one dryer unit which comprises at least one downwardly open single-wire draw group, and in which paper, board and/or finishing process, in or after the dryer unit, or both in and after the dryer unit, the web is subjected to an operation selected from the group consisting of reeling, calendering, intermediate calendering, coating, and additional drying, wherein the air impingement produced in the web treatment zone by the air impingement arrangement and directed at the web includes, one following after the other, at least one hot blowing with air and at least one cold blowing with air.

35. The air impingement arrangement of claim 34, wherein moisture condenses and/or is absorbed into the web in cold air blowing, such that the curl behaviour of the web changes to the range of structural, reversible, curl behaviour.

36. The air impingement arrangement of claim 34, wherein the air impingement in the web treatment zone of the web is applied to a free surface of the web.

37. The air impingement arrangement of claim 34, wherein the air impingement in the web treatment zone takes place through a drying wire located on the web.

38. The air impingement arrangement of claim 34 wherein the air impingement arrangement includes at least one hood placed on top of a drying cylinder, a suction roll, an air impingement roll or a cooling cylinder.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

39. The air impingement arrangement of claim 38, wherein the air impingement arrangement is in connection with the last drying cylinder, suction roll, air impingement roll or cooling cylinder of the dryer unit, and that the air impingement arrangement comprises a bipartite hood which is divided by a partition wall into two sections, in which connection, in a machine direction, the web is first subjected to a blowing with hot air from a hot blowing part of the bipartite hood and after that to a blowing with cold air from a cold blowing part of the bipartite hood.

40. The air impingement arrangement of claim 39, wherein the air treatment zone of the web comprises a first and a second area which are defined by the bipartite hood at said hood and which extend across the width of the web.

41. The air impingement arrangement of claim 38, wherein the air impingement arrangement comprises two successive and separate hoods placed on top of two successive drying cylinders, suction rolls, air impingement rolls or cooling cylinders, the first of the hoods being a hot blowing part blowing hot air and the latter of the hoods being a cold blowing part blowing cold air.

42. The air impingement arrangement of claim 41, wherein the air treatment zone of the web is bipartite and comprises separately a first area which extends across the width of the web and is located at the hot blowing part placed first in a machine direction, and a second area which extends across the width of the web and is located at the cold blowing part placed after that in a machine direction.

43. The air impingement arrangement of claim 41, wherein the hood located first in a machine direction is in connection with the a second last drying cylinder, suction roll, air impingement roll or cooling cylinder, and that the hood located after that in a machine direction is in connection with a last drying cylinder, suction roll, air impingement roll or cooling cylinder.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

44. The air impingement arrangement of claim 38, wherein the air impingement arrangement comprises a hood which is arranged in connection with a drying cylinder, suction roll, air impingement roll or cooling cylinder and which is a hot blowing part blowing hot air against the web, and a blow box or an airborne drying unit which extends across the web and which is a cold blowing part blowing cold air against the web.

45. The air impingement arrangement of claim 44, wherein the air treatment zone of the web is bipartite and comprises separately a first area which extends across the width of the web and is located at the hood blowing hot air, and a second area which extends across the width of the web and is located at a blow box or an airborne drying unit blowing cold air.

46. The air impingement arrangement of claim 44, wherein the air impingement arrangement is in connection with a last drying cylinder, suction roll, air impingement roll or cooling cylinder of the dryer unit.

47. The air impingement arrangement of claim 34, wherein in order to cool the web further before it is processed further, a cooling cylinder is additionally arranged to cool the web in the air treatment zone or after it.

48. The air impingement arrangement of claim 34, wherein the temperature of air of the cold blowing part is below 50 °C.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

49. A method for air impingement in order to compensate for the curling tendency of a paper or board web treated in connection with a paper or board process or with a related finishing process, in which air impingement method a contact-free web treatment zone is formed, which treatment zone is extended to cover substantially the entire width of the web, in which paper, board and/or finishing process the web is dried in at least one dryer unit, which comprises one or more downwardly open single-wire draw groups, and in which paper, board and/or finishing process, in the dryer unit, or after the dry unit, or in and after the dryer unit, the web is subjected to at least one operation which is selected from the group consisting of reeling, calendering, intermediate calendering, coating, and additional drying, wherein, in at least one web treatment zone, the web is subjected to impingement blowing with air, in which connection the web is first subjected to at least one hot air blowing and after that to at least one cold air blowing.

50. The air impingement method of claim 49, wherein moisture is condensed and/or absorbed into the web by said cold air blowing, whereby the curl behaviour of the web is changed to the range of structural, reversible, curl behaviour.

51. The air impingement method of claim 49, wherein the air impingement in the web treatment zone is directed directly at a free surface of the web.

52. The air impingement method of claim 49, wherein the cold air blowing is directed at the web from above the web through a drying wire.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

53. The air impingement method of claim 49, wherein at least one hood is used for air impingement, which hood is placed on top of a drying cylinder, a suction roll, an air impingement roll or a cooling cylinder and by means of which, in a machine direction, a blowing with hot air is first blown against the web from a hot blowing part and after that a blowing with cold air from a cold blowing part, said drying cylinder, suction roll, air impingement roll or cooling cylinder being disposed in connection with the last drying cylinder, suction roll, air impingement roll or cooling cylinder of the dryer unit and divided into two sections by a partition wall.

54. The air impingement method of claim 49, wherein two separate hoods are used for air impingement, said hoods being placed on top of two successive drying cylinders, suction rolls, air impingement rolls or cooling cylinders disposed as the last cylinders/rolls in the dryer unit, hot air being blown through the hood which is placed first in a machine direction and which is a hot blowing part blowing hot air and located in connection with the second last drying cylinder, suction roll, air impingement roll or cooling cylinder, and cold air being blown through the hood which is placed further down in a machine direction and which is a cold blowing part blowing cold air and located in connection with the last drying cylinder, suction roll, air impingement roll or cooling cylinder.

55. The air impingement method of claim 49, wherein for air impingement are used a hood arranged on top of and in connection with the last drying cylinder, suction roll, air impingement roll or cooling cylinder of the dryer unit, said hood being a hot blowing part blowing hot air against the web, and a blow box or an airborne drying unit which extends across the width of the web and which is a cold blowing part blowing cold air against the web.

56. The air impingement method of claim 49, wherein the web is further cooled during air impingement or after it by a cooling cylinder.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

57. The air impingement method of claim 49 wherein the temperature of air in the cold blowing part is below 50° C.

58. A paper or board machine comprising:
a former unit for a paper or board web;
a press unit; and
at least one dryer unit, wherein, for the purpose of compensating for the curl of the web, the web is subjected to at least one air impingement which, arranged in connection with a paper or board process or with a related finishing process, extends substantially across the entire width of the web running in the vicinity of the air impingement and forms a contact-free web treatment zone with the web, wherein the air impingement applied to the web includes, following one after the other, at least one hot blowing and at least one cold blowing with air.

59. The paper or board machine of claim 58, wherein moisture condenses and/or is absorbed into the web in cold blowing, and the curl behaviour of the web changes to the range of structural, reversible, curl behaviour.

60. The paper or board machine of claim 58 wherein the air impingement in the air treatment zone of the web is applied to a free surface of the web.

61. The paper or board machine of claim 58, wherein the air impingement in the air treatment zone of the web is applied to the web through a drying wire located on the web.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

62. The paper or board machine of claim 58, wherein each air impingement arrangement includes at least one hood which is placed on top of the last drying cylinder, suction roll, air impingement roll or cooling cylinder of the dryer unit and divided by a partition wall, in which connection, in a machine direction, the web is first subjected to a blowing with hot air from a hot blowing part of the hood and after that to a blowing with cold air from a cold blowing part of the hood.

63. The paper or board machine of claim 58, wherein the air impingement arrangement comprises two successive and separate hoods placed on top of the last drying cylinders, suction rolls, air impingement rolls and/or cooling cylinders of the dryer unit, in which connection, in a machine direction, the web is first subjected to a blowing with hot air from the first hood serving as a hot blowing part and after that to a blowing with cold air from the second hood serving as a cold blowing part.

64. The paper or board machine of claim 58, wherein the air impingement arrangement comprises a hood which is placed first in a machine direction on top of a last drying cylinder, suction roll, air impingement roll or cooling cylinder of the dryer unit and which serves as a hot blowing part and blows hot air against the web; and a blow box or an airborne drying unit which extends across the entire width of the web and which serves as a cold blowing part and blows cold air against the web.

65. The paper or board machine of claim 58 further comprising a cooling cylinder which acts on the web in a machine direction during or after air impingement.

66. The paper or board machine of claim 58, wherein the temperature of air of the cold blowing part is below 50 °C.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

67. A paper machine having an air impingement arrangement for compensating for the curling tendency of a paper or board web which is being treated, the paper machine comprising:

- a dryer unit having a first end roll, and a second end roll positioned upstream of the end roll;
- a web passing from the second end roll to the first end roll;
- a first hood portion which extends substantially across the entire width of the web running in the vicinity thereof and forms a contact-free first web treatment zone where the web passes over one of the end rolls, the first hood portion discharging hot air onto the first web treatment zone; and
- a second hood portion which extends substantially across the entire width of the web running in the vicinity thereof and forms a contact-free second web treatment zone where the web passes over one of the end rolls downstream of the first web treatment zone, the second hood portion discharging cold air at a lower temperature than the hot air onto the second web treatment zone.

68. The paper machine of claim 67 wherein the first web treatment zone and the second web treatment zone are both formed over portions of the first end roll, and the first hood portion and the second hood portion are part of a single bipartite hood which is divided by a partition wall.

69. The paper machine of claim 67 wherein the first web treatment zone is formed over portions of the second end roll, and the second web treatment zone is formed over portions of the first end roll.

70. The paper machine of claim 67 wherein the a drying wire is disposed over the web as it passes through the first web treatment zone and the second web treatment zone.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

71. The paper machine of claim 67 further comprising a cooling cylinder downstream of the first end roll, over which the web travels after passing through the second web treatment zone.

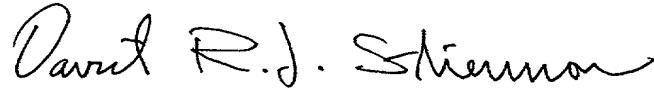
72. The paper machine of claim 67, wherein the temperature of air of the cold blowing part is below 50 °C.

REMARKS

Claims 34–72 remain pending in the application.

Applicant believes that no new matter has been added by these amendments and that the application, as amended, is ready for examination. Favorable action thereon is respectfully solicited.

Respectfully submitted,



David R. J. Stiennon, Reg. No. 33212
Attorney for Applicant
Lathrop & Clark LLP
740 Regent Street, Suite 400, P.O. Box 1507
Madison, Wisconsin 53701-1507
(608) 257-7766

Amdt1.res

In The United States Patent And Trademark Office

Applicant: Pasi Ahonen, et al. Date: November 8, 2001
Date Filed: Simultaneously herewith Docket No.: FORSAL-27
PCT App. No.: PCT/FI00/00410
For: Method and Arrangement of Impingement for Blowing Compensation of a Tendency of Curling of a Paper Board Web to be Treated as Well as a Paper or Board Machine

Certificate of Express Mailing

I hereby certify that this document is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 35 C.F.R. §1.10 on 8 November 2001 with Mailing Label No. EV015 203 645 US and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

David R. J. Stiennon

Signature

David R. J. Stiennon, Reg. No. 33212

Name of applicant, assignee or Registered Representative

Preliminary Amendment

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

Prior to examination of the above application, please amend the application as follows.

In the Specification:

Please amend the specification as shown on the accompanying Clean Copy of Substitute Specification. A Marked Up Copy of Substitute Specification is also provided, as well as a Statement as to Lack of New Matter under 37 C.F.R. 1.125(b)(1).

In the Claims:

Please cancel claims 1-33.

Please add the following new claims:

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

34. An air impingement arrangement for compensating for the curling tendency of a paper or board web which is being treated, which air impingement arrangement is disposed in connection with a paper or board process or with a related finishing process and extends substantially across the entire width of the web running in the vicinity thereof and forms a contact-free web treatment zone, in which paper, board and/or finishing process the web is dried in at least one dryer unit which comprises at least one downwardly open single-wire draw group, and in which paper, board and/or finishing process, in or after the dryer unit, or both in and after the dryer unit, the web is subjected to an operation selected from the group consisting of reeling, calendering, intermediate calendering, coating, and additional drying, wherein the air impingement produced in the web treatment zone by the air impingement arrangement and directed at the web includes, one following after the other, at least one hot blowing with air and at least one cold blowing with air.

35. The air impingement arrangement of claim 34, wherein moisture condenses and/or is absorbed into the web in cold air blowing, such that the curl behaviour of the web changes to the range of structural, reversible, curl behaviour.

36. The air impingement arrangement of claim 34, wherein the air impingement in the web treatment zone of the web is applied to a free surface of the web.

37. The air impingement arrangement of claim 34, wherein the air impingement in the web treatment zone takes place through a drying wire located on the web.

38. The air impingement arrangement of claim 34 wherein the air impingement arrangement includes at least one hood placed on top of a drying cylinder, a suction roll, an air impingement roll or a cooling cylinder.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

39. The air impingement arrangement of claim 38, wherein the air impingement arrangement is in connection with the last drying cylinder, suction roll, air impingement roll or cooling cylinder of the dryer unit, and that the air impingement arrangement comprises a bipartite hood which is divided by a partition wall into two sections, in which connection, in a machine direction, the web is first subjected to a blowing with hot air from a hot blowing part of the bipartite hood and after that to a blowing with cold air from a cold blowing part of the bipartite hood.

40. The air impingement arrangement of claim 39, wherein the air treatment zone of the web comprises a first and a second area which are defined by the bipartite hood at said hood and which extend across the width of the web.

41. The air impingement arrangement of claim 38, wherein the air impingement arrangement comprises two successive and separate hoods placed on top of two successive drying cylinders, suction rolls, air impingement rolls or cooling cylinders, the first of the hoods being a hot blowing part blowing hot air and the latter of the hoods being a cold blowing part blowing cold air.

42. The air impingement arrangement of claim 41, wherein the air treatment zone of the web is bipartite and comprises separately a first area which extends across the width of the web and is located at the hot blowing part placed first in a machine direction, and a second area which extends across the width of the web and is located at the cold blowing part placed after that in a machine direction.

43. The air impingement arrangement of claim 41, wherein the hood located first in a machine direction is in connection with the a second last drying cylinder, suction roll, air impingement roll or cooling cylinder, and that the hood located after that in a machine direction is in connection with a last drying cylinder, suction roll, air impingement roll or cooling cylinder.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

44. The air impingement arrangement of claim 38, wherein the air impingement arrangement comprises a hood which is arranged in connection with a drying cylinder, suction roll, air impingement roll or cooling cylinder and which is a hot blowing part blowing hot air against the web, and a blow box or an airborne drying unit which extends across the web and which is a cold blowing part blowing cold air against the web.

45. The air impingement arrangement of claim 44, wherein the air treatment zone of the web is bipartite and comprises separately a first area which extends across the width of the web and is located at the hood blowing hot air, and a second area which extends across the width of the web and is located at a blow box or an airborne drying unit blowing cold air.

46. The air impingement arrangement of claim 44, wherein the air impingement arrangement is in connection with a last drying cylinder, suction roll, air impingement roll or cooling cylinder of the dryer unit.

47. The air impingement arrangement of claim 34, wherein in order to cool the web further before it is processed further, a cooling cylinder is additionally arranged to cool the web in the air treatment zone or after it.

48. The air impingement arrangement of claim 34, wherein the temperature of air of the cold blowing part is below 50 °C.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

49. A method for air impingement in order to compensate for the curling tendency of a paper or board web treated in connection with a paper or board process or with a related finishing process, in which air impingement method a contact-free web treatment zone is formed, which treatment zone is extended to cover substantially the entire width of the web, in which paper, board and/or finishing process the web is dried in at least one dryer unit, which comprises one or more downwardly open single-wire draw groups, and in which paper, board and/or finishing process, in the dryer unit, or after the dry unit, or in and after the dryer unit, the web is subjected to at least one operation which is selected from the group consisting of reeling, calendering, intermediate calendering, coating, and additional drying, wherein, in at least one web treatment zone, the web is subjected to impingement blowing with air, in which connection the web is first subjected to at least one hot air blowing and after that to at least one cold air blowing.

50. The air impingement method of claim 49, wherein moisture is condensed and/or absorbed into the web by said cold air blowing, whereby the curl behaviour of the web is changed to the range of structural, reversible, curl behaviour.

51. The air impingement method of claim 49, wherein the air impingement in the web treatment zone is directed directly at a free surface of the web.

52. The air impingement method of claim 49, wherein the cold air blowing is directed at the web from above the web through a drying wire.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

53. The air impingement method of claim 49, wherein at least one hood is used for air impingement, which hood is placed on top of a drying cylinder, a suction roll, an air impingement roll or a cooling cylinder and by means of which, in a machine direction, a blowing with hot air is first blown against the web from a hot blowing part and after that a blowing with cold air from a cold blowing part, said drying cylinder, suction roll, air impingement roll or cooling cylinder being disposed in connection with the last drying cylinder, suction roll, air impingement roll or cooling cylinder of the dryer unit and divided into two sections by a partition wall.

54. The air impingement method of claim 49, wherein two separate hoods are used for air impingement, said hoods being placed on top of two successive drying cylinders, suction rolls, air impingement rolls or cooling cylinders disposed as the last cylinders/rolls in the dryer unit, hot air being blown through the hood which is placed first in a machine direction and which is a hot blowing part blowing hot air and located in connection with the second last drying cylinder, suction roll, air impingement roll or cooling cylinder, and cold air being blown through the hood which is placed further down in a machine direction and which is a cold blowing part blowing cold air and located in connection with the last drying cylinder, suction roll, air impingement roll or cooling cylinder.

55. The air impingement method of claim 49, wherein for air impingement are used a hood arranged on top of and in connection with the last drying cylinder, suction roll, air impingement roll or cooling cylinder of the dryer unit, said hood being a hot blowing part blowing hot air against the web, and a blow box or an airborne drying unit which extends across the width of the web and which is a cold blowing part blowing cold air against the web.

56. The air impingement method of claim 49, wherein the web is further cooled during air impingement or after it by a cooling cylinder.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

57. The air impingement method of claim 49 wherein the temperature of air in the cold blowing part is below 50° C.

58. A paper or board machine comprising:
a former unit for a paper or board web;
a press unit; and
at least one dryer unit, wherein, for the purpose of compensating for the curl of the web, the web is subjected to at least one air impingement which, arranged in connection with a paper or board process or with a related finishing process, extends substantially across the entire width of the web running in the vicinity of the air impingement and forms a contact-free web treatment zone with the web, wherein the air impingement applied to the web includes, following one after the other, at least one hot blowing and at least one cold blowing with air.

59. The paper or board machine of claim 58, wherein moisture condenses and/or is absorbed into the web in cold blowing, and the curl behaviour of the web changes to the range of structural, reversible, curl behaviour.

60. The paper or board machine of claim 58 wherein the air impingement in the air treatment zone of the web is applied to a free surface of the web.

61. The paper or board machine of claim 58, wherein the air impingement in the air treatment zone of the web is applied to the web through a drying wire located on the web.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

62. The paper or board machine of claim 58, wherein each air impingement arrangement includes at least one hood which is placed on top of the last drying cylinder, suction roll, air impingement roll or cooling cylinder of the dryer unit and divided by a partition wall, in which connection, in a machine direction, the web is first subjected to a blowing with hot air from a hot blowing part of the hood and after that to a blowing with cold air from a cold blowing part of the hood.

63. The paper or board machine of claim 58, wherein the air impingement arrangement comprises two successive and separate hoods placed on top of the last drying cylinders, suction rolls, air impingement rolls and/or cooling cylinders of the dryer unit, in which connection, in a machine direction, the web is first subjected to a blowing with hot air from the first hood serving as a hot blowing part and after that to a blowing with cold air from the second hood serving as a cold blowing part.

64. The paper or board machine of claim 58, wherein the air impingement arrangement comprises a hood which is placed first in a machine direction on top of a last drying cylinder, suction roll, air impingement roll or cooling cylinder of the dryer unit and which serves as a hot blowing part and blows hot air against the web; and a blow box or an airborne drying unit which extends across the entire width of the web and which serves as a cold blowing part and blows cold air against the web.

65. The paper or board machine of claim 58 further comprising a cooling cylinder which acts on the web in a machine direction during or after air impingement.

66. The paper or board machine of claim 58, wherein the temperature of air of the cold blowing part is below 50 °C.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

67. A paper machine having an air impingement arrangement for compensating for the curling tendency of a paper or board web which is being treated, the paper machine comprising:

- a dryer unit having a first end roll, and a second end roll positioned upstream of the end roll;
- a web passing from the second end roll to the first end roll;
- a first hood portion which extends substantially across the entire width of the web running in the vicinity thereof and forms a contact-free first web treatment zone where the web passes over one of the end rolls, the first hood portion discharging hot air onto the first web treatment zone; and
- a second hood portion which extends substantially across the entire width of the web running in the vicinity thereof and forms a contact-free second web treatment zone where the web passes over one of the end rolls downstream of the first web treatment zone, the second hood portion discharging cold air at a lower temperature than the hot air onto the second web treatment zone.

68. The paper machine of claim 67 wherein the first web treatment zone and the second web treatment zone are both formed over portions of the first end roll, and the first hood portion and the second hood portion are part of a single bipartite hood which is divided by a partition wall.

69. The paper machine of claim 67 wherein the first web treatment zone is formed over portions of the second end roll, and the second web treatment zone is formed over portions of the first end roll.

70. The paper machine of claim 67 wherein the a drying wire is disposed over the web as it passes through the first web treatment zone and the second web treatment zone.

Applicant: Pasi Ahonen, et al.
PCT App. No.: PCT/FI00/00410

71. The paper machine of claim 67 further comprising a cooling cylinder downstream of the first end roll, over which the web travels after passing through the second web treatment zone.

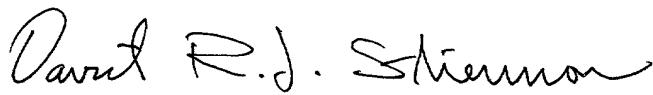
72. The paper machine of claim 67, wherein the temperature of air of the cold blowing part is below 50 °C.

REMARKS

Claims 34–72 remain pending in the application.

Applicant believes that no new matter has been added by these amendments and that the application, as amended, is ready for examination. Favorable action thereon is respectfully solicited.

Respectfully submitted,



David R. J. Stiennon, Reg. No. 33212
Attorney for Applicant
Lathrop & Clark LLP
740 Regent Street, Suite 400, P.O. Box 1507
Madison, Wisconsin 53701-1507
(608) 257-7766

Amdt1.res

Patent Application

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Pasi Ahonen, et al.

Date: November 8, 2001

Date Filed: Simultaneously herewith

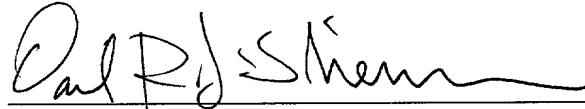
Docket No.: FORSAL-27

PCT App. No.: PCT/FI00/00410

For: Method and Arrangement of Impingement for Blowing Compensation of a Tendency of Curling of a Paper Board Web to be Treated as Well as a Paper or Board Machine

Certificate of Express Mailing

I hereby certify that this correspondence is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 35 C.F.R. §1.10 on 11/08/2001 with Mailing Label No. EV 015 203 645 US and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231



Signature

David R. J. Stiennon, Reg. No. 33212

Name of applicant, assignee or Registered Representative

Submission of Substitute Specification

Under 37 C.F.R. § 1.125

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

A substitute specification, excluding the claims, is filed herewith under the provisions of 37 C.F.R. § 1.125(b).

1. The substitute specification contains no new matter.

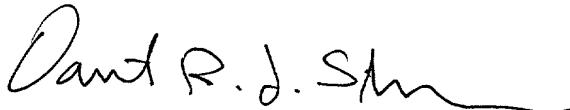
Applicant: Pasi Ahonen, et al.

JC10 Rec'd PCT/PTO 08 NOV 2001

2. A marked-up copy of the substitute specification showing the matter being added to and the matter being deleted from the specification of record accompanies this paper. The matter being added is underlined, and the matter being deleted is shown by brackets.
3. The substitute specification is submitted in clean form without markings as to amended material.

Applicant requests that the accompanying substitute specification be entered in the application record.

Respectfully submitted,



David R. J. Stiennon, Reg. No. 33212
Attorney for Applicant
Lathrop & Clark
740 Regent Street, Suite 400
P.O. Box 1507
Madison, Wisconsin 53701-1507
(608) 257-7766

tSubSpec.res

10/009095

In The United States Patent And Trademark Office

Applicant: Pasi Ahonen, et al. Date: November 8, 2001

Date Filed: Simultaneously herewith Docket No.: FORSAL-27

PCT App. No.: PCT/FI00/00410

For: Method and Arrangement of Impingement for Blowing Compensation of a Tendency of Curling of a Paper Board Web to be Treated as Well as a Paper or Board Machine

Certificate of Express Mailing

I hereby certify that this document is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 35 C.F.R. §1.10

on 11/8/01

with Mailing Label No. EV015203645VS
and is addressed to the Assistant Commissioner for Patents,
Washington, D.C. 20231.

David R. J. Stiennon

Signature

David R. J. Stiennon, Reg. No. 33212

Name of applicant, assignee or Registered Representative

Marked Up Copy of Substitute Specification under 37 C.F.R. 1.125(b)(2)

Deletions are shown with the following attributes and color:

Bold, (No color code).

Deleted text is shown as full text.

Deletions are surrounded by brackets [].

Insertions are shown with the following attributes and color:

Bold, Underline, (No color code).

TITLE OF THE INVENTION

Method and **[a]**Arrangement of **[i]**Impingement

for **[b]**Blowing **[c]**Compensation **[**

]of a [t]Tendency of **[C]**curling of a **[p]**Paper **[b]**Board **[w]**Web

to be **[t]**Treated as **[w]**Well as **[**

]a [p]Paper or **[b]**Board **[m]**achine

5

Machine

CROSS REFERENCES TO RELATED APPLICATIONS

[0001] This application is a national stage application of PCT Application No. PCT/FI00/00410, filed May 9, 2000, and claims priority on Finnish Application No. 991079, filed May 10, 1999, the disclosures of both of which applications are incorporated by reference herein.

STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER FEDERALLY SPONSORED RESEARCH AND DEVELOPMENT

Not applicable.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to paper [or board machines. More specifically, the present invention relates to an air impingement arrangement according to the preamble of claim 1 and to an]and board machine air impingement [method according to the preamble of claim 16 as well as to a paper or board machine according to the preamble of claim 25]methods and apparatus for compensating for the curling tendency of a paper or board web[to be treated].

[0003] As known in the prior art, multi-cylinder dryer units of a paper machine employ twin-wire draw and/or single-wire draw. In twin-wire draw, the drying cylinder groups comprise two wires which press the web one from above and the other from below against heated cylinder surfaces. Between the drying cylinder rows, generally horizontal rows, there are free and unsupported draws, in which connection the web is susceptible to fluttering, which may cause web breaks, especially when the web is still moist and therefore weak. For this reason, single wire draw has recently been adopted and applied in the dryer unit in practice without an exception, each drying cylinder group of the single wire draw including only one drying wire, on support of which the web runs through the entire group such that, on

the [crying]drying cylinders, the drying wire presses the web against heated cylinder surfaces, and on the reversing cylinders or rolls between the drying cylinders, the web runs on the outer surface of the drying wire. Typically, the dryer unit of a paper machine comprises 20-30 drying cylinders and reversing cylinders, in which connection a multi-cylinder dryer has 5-8 wire groups and the groups located at the upstream end of the dryer unit are normally shorter than the groups at the downstream end thereof.

[0004] In so-called normal single-wire draw groups of the prior art, the heated drying cylinders are located in an upper row and the reversing cylinders are located in lower rows, which rows are commonly horizontal and parallel to one another. The applicant's *FI patent 54627* (corresponding *US patent 4,202,113*) proposes placing successively above-mentioned normal single-wire groups and so-called inverted single-wire groups, in which heated drying cylinders are located in a lower row and reversing suction cylinders or rolls are located in an upper row with the main purpose of drying the web symmetrically on both sides thereof. Beloit Corp. have also put forward some proposals for dryer units comprising normal and inverted cylinder groups, in respect of which reference is made to international application publications *WO 88/06204* and *WO 88/06205* and to *US patent 4,934,067*, which proposes inverted groups for a dryer unit for control of curl. According to *US patent 5,269,074* (Beloit Corp.), a long dryer unit applying single-wire draw is followed by a short dryer unit applying twin-wire draw with the purpose of controlling curl of the web.

[0005] The use of moist steam for straightening curl has already been known in the art since the 1970's and the 1980's, as appears in *US patent 3,948,721* (Vinheim Karl) or in *US patent 5,557,860* (Voith) and in public *FI patent application 821431*, which teaches passing the web through a steam treatment station in order to straighten curl. Recently, dryer units provided with single-wire draw have become common in which the upper or lower cylinders are steam-heated drying cylinders, the web coming into direct contact with said cylinders while being pressed by the

drying wire, and in which the lower or upper cylinders are cylinders provided with internal suction, for example, [the applicant's] **Metso Paper, Inc.**'s so-called **VAC-ROLL™** cylinders in which a vacuum effect is directed through the perforated shell of the cylinders from the interior space of the reversing cylinder to the grooves extending around the shell of the cylinder. Said vacuum effect serves to maintain the web in contact with the drying wire when the web comes to the side of the outside curve on the reversing cylinders. At the same time, the transverse shrinkage of the web is sought to be prevented while drying progresses.

[0006] In paper and board machines, the reeling of the web is usually sought to be carried out when the web is as cold as possible, and in order to achieve this aim, it is prior known that a cooling cylinder is used at the end of the dryer unit. In accordance with the commonly known state of the art, the cooling of the web has the following effects:

- the relaxation time of the web can be shortened, which leads to smaller differences of stress in the web before the next process stage (e.g. calendering or reeling) as compared with a situation that the web is passed forwards at a higher temperature,
- the temperature differences themselves can be reduced by lowering temperature level, which leads to smaller differences in the elastic-plastic behaviour of the web in the next process stage or before it.

[0007] The most substantial problem associated with single-wire draw is that drying heating is directed, i.e. by convection from the surface of a heated drying cylinder, more intensely only at one surface of the web from one direction. As a result of this one-direction heating, there arises a strong tendency to curl in the web. This problem is also previously known and in order to deal with it, several different solutions have been proposed in the course of years. However, it is common to all these solutions that there remain in the web more or less internal stresses which will release in an unpredictable manner at a later stage and may cause problems as soon

as in connection with finishing, such as coating and reeling, or later at the stage at which the paper product is utilized.

[0008] With respect to this complex of problems and the prior art associated with the background of the invention, reference is further made to the publications

5 **[0009]** FI 902616[

]describes a steam box disposed in a dryer unit for relaxation of drying stresses and thus for compensating for curl.

[0010] FI 931263[

10]describes air impingement against a large cylinder which has a diameter > 2 m and which is placed inside a drying wire loop. Said publication proposes the division of air impingement into sections, in which connection each section uses hot air or superheated steam having a temperature, moisture and/or pressure which is different in each section in order to prevent transverse shrinkage of the web, to control drying of the web and to achieve a desired moisture profile for the web.

[0011] FI 950434[

20]proposes passing a web, which has a tendency to curl because of the nonsymmetrical forward-drying of the bottom and top surfaces of the web, to finishing in which the tendencies to curl are compensated for by moistening and/or plastically working the web.

[0012] FI 951748[

]describes a dryer unit which applies single-wire draw for control of curl and in which the last group is inverted to allow drying on both sides.

[0013] FI 963734[

25]proposes an arrangement for drying a coated paper web in a drying group

of an after-dryer unit applying single-wire draw, the web being treated in said arrangement after that by means of a steam box in order to compensate for the tendency to curl.

[0014] FI 964830[

5] proposes an arrangement for compensating for the curling tendency of a paper web by means of an air impingement device which is placed above a drying cylinder and by which hot moist air is blown against the web.

[0015] FI 971301[

10] discloses an arrangement for controlling the curl of a paper web by means of a dryer unit. According to said arrangement, the necessary operations are carried out in several stages while the temperature of the web is below 85 °C. According to the publication, the curl control treatment is accomplished by means of a steam box or a moistening device.

[0016] FI 971713[

15] proposes arranging a large-diameter air impingement drying cylinder in connection with a dryer unit which applies single-wire draw and has drying cylinders placed below and reversing cylinders placed above, which air impingement drying cylinder is placed inside a drying wire loop and on top or in the vicinity of which cylinder, at both sides, heated smaller-diameter cylinders are placed, whereby, when the web is supported by the drying wire over the entire length of the dryer unit, uneven transverse shrinkage of the web can be prevented and avoided.

[0017] FI 972080[

20] proposes disposing a steam box and/or a moistening device and/or an infrared dryer after a calender or, if calendering is not employed, in connection with a machine reel or in connection with the finishing process

after it in order to compensate for curl of a web.

5 [0018] Despite numerous approaches of the prior art, it has not been possible to eliminate the curl of the web in paper or board machines and, recently, with increasing running speeds, the curling tendency has been also increased by the more and more common demand for downwardly open dryer units applying single-wire draw to be disposed in paper or board machines in order that the paper or board machine might be placed in a smaller, i.e. lower hall space and that, at the same time, the serviceability of the dryer unit might be improved and the contamination problems kept small. Indeed, a substantial problem with the manufacture of paper and board is still that the control of the profileability of the web is slow, and different elongation streaks, waves or curls arise because of drying stresses, and that paper or board subjected to unequal-sided drying, in particular thin paper grades, such as different directory papers, exhibits very intense wave formation and curl when they come into contact with the moisture of air after the manufacturing process.

10

15

SUMMARY OF THE INVENTION

20 [0019] The primary object of the present invention is to improve compensation for the curling tendency of a paper or board web and attempt to minimize drying stresses arising in the web and to bring the curling tendency of the web to the range of reversible, or structural curl behaviour, in which connection the web is as free as possible from stresses and cooled for being wound as cold as possible. One further object of the invention is also to make control of the profileability of the web quicker and to increase drying capacity in connection with single-wire draws.

25 **[This primary object of the present invention is achieved by means of an air impingement arrangement of the kind mentioned at the beginning, the special features characteristic of said arrangement being set forth in the independent claim 1 of the accompanying set of claims, by means of an air impingement method, the special features characteristic of said method being set forth in the**

independent claim 16 of the accompanying set of claims, and by means of a paper or board machine, the special features characteristic of said machine being set forth in the independent claim 25 of the accompanying set of claims.

5 **[J0020]** Thus, the invention is based on a new and inventive basic idea that, in order to minimize the drying stresses of a web, in at least one zone in which the web is treated with air and which extends substantially across the entire width of the web, air impingement directed at the web includes, one following after the other, at least one hot air blowing and at least one cold air blowing in which the cold air used is 10 hall air from the machinery hall surrounding the paper or board machine, cooled hall air and/or moistened hall air. The moisture of such hall air condenses when the air comes into an environment which is warmer than the air, with the result that the web in cold air impingement is not only cooled but also moistened by the action of the 15 blowing air because condensed moisture is condensed and/or absorbed into the web, in which connection the curl behaviour of the web changes with moisture to the range of structural, i.e. reversible curl behaviour, which is conducive to substantially compensating for the curling tendency of paper or board.

20 **[J0021]** In accordance with the invention, it is advantageous that an air impingement arrangement is arranged in a hood which is located above a drying cylinder, a suction roll or an air-impingement roll, which is advantageously the last drying cylinder, suction roll or air-impingement roll of a dryer unit, and which hood is divided with a partition wall into two sections, in which connection the web is subjected in the machine direction first to a blowing with hot air and after that to a 25 blowing with cold air. In that connection, the air treatment zone of the web comprises a first and a second area which are defined by the bipartite hood at said hood and which extend across the width of the web. In that connection, depending on the drying wire loop arrangement, air impingement can be applied either directly to the free surface of the web or to the free surface of the drying wire located on the web. As an alternative to a bipartite hood, the air impingement arrangement can comprise in accordance with the invention

5

- Two successive hoods placed on top of two successive drying cylinders, suction rolls and/or air impingement rolls, in which connection the former hood in the machine direction is advantageously located in connection with the second last drying cylinder, suction roll or air impingement roll and blows hot air against the web and the latter hood in the machine direction is advantageously located in connection with the last drying cylinder, suction roll or air impingement roll and blows cold air against the web. In that connection, the zone for air treatment of the web is bipartite and comprises separately a first area extending across the width of the web and located at the hood blowing hot air and a second area extending across the width of the web and located at the hood blowing cold air;

10

- A hood arranged in connection with a drying cylinder, a suction roll or an air impingement roll, which is advantageously the last drying cylinder, suction roll or air impingement roll of a dryer unit, which hood blows hot air against the web, and a blow box or an airborne drying unit extending across the web and blowing cold air against the web. In that connection, the zone for air treatment of the web is bipartite and comprises separately a first area extending across the width of the web and located at the hood blowing hot air and a second area extending across the width of the web and located at the blow box or the airborne drying unit blowing cold air.

15

20

[0022] In accordance with the embodiments of the invention regarded as preferable, it is advantageous that the temperature of the cold air blowing is $\leq 50^{\circ}\text{C}$. For the purpose of cooling the web further before its further treatment, a cooling cylinder can be arranged to cool the web after the air treatment zone.

[0023] With respect to the benefits of the invention, it may be mentioned that

25

- balanced drying can be achieved which minimizes the drying stresses arising in paper,
- cooling of the web before calendering equalizes the temperature differences and temperature profiles appearing in it,
- cooling has been found to generally have a favourable effect on the relaxation of

the web,

- when drying takes place by air impingement, crystallization of lignin caused by single-wire draw cylinders can be avoided and final drying can be carried out at low temperatures,
- 5 - the drying capacity of single-wire draw increases substantially, even by 10-15 %,
- control of drying and cooling is quick and therefore the web can be profiled quickly,
- when cooling cold air blowing is coupled with hot air blowing, energy can be saved,
- 10 - air impingement according to the invention can be applied both in a forward-dryer section and in an after-dryer section,
- because of the downwardly open structure, the air impingement arrangement according to the invention makes it possible in a paper or board machine that removal of broke and cleaning of the unit can be carried out directly from machine level and from below the hood,
- 15 - when single-wire draw is provided simultaneously with the air impingement arrangement according to the invention, blowers and other auxiliary devices can be placed on the lower level which becomes free or, especially in connection with new machines, the basement space can be left unbuilt altogether in the area of cylinder drying,
- 20 - when compared with the cooling of the web accomplished by means of cooling cylinders and on the water-jet principle, the air impingement arrangement according to the invention is
 - clean because no drip water problem is encountered in the invention,
 - advantageous because no displacements of cylinders and a reel are needed, and it also
 - requires little space, is economical in terms of energy and easy to operate,
- 25 - the air impingement according to the invention is suitable for use both in on- and off-machine dryer sections and calenders, and can also be located in the middle of a dryer section, for example, in on-machine calendering and in intermediate calendering, and

- it can be applied both to coated and to uncoated papers and boards.

[0024] With respect to other special features of the invention and to the advantages attainable by them, reference is made to the dependent claims of the accompanying set of claims.

5

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The invention will be described below with reference to the accompanying drawing in which

[0026] FIG. 1 shows generally a paper or board machine which is provided with an air impingement arrangement in accordance with a first advantageous embodiment of the invention,

[0027] FIG. 2 shows the air impingement arrangement in accordance with the first advantageous embodiment of the invention in more detail,

[0028] FIG. 3 shows an alternative air impingement arrangement of the first advantageous embodiment of the invention,

[0029] FIG. 4 shows an air impingement arrangement in accordance with a second embodiment of the invention regarded as advantageous,

[0030] FIG. 5 shows an alternative air impingement arrangement of the second advantageous embodiment of the invention,

[0031] FIG. 6 shows an air impingement arrangement in accordance with a third embodiment of the invention regarded as advantageous,

[0032] FIG. 7 shows an alternative air impingement arrangement of the third advantageous embodiment of the invention, and

[0033] FIG. 8 illustrates the change of curling tendency as a function of moisture content in connection with air impingement in accordance with the invention.

25

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0034] Fig.1 shows an LWC paper machine which includes:

- a unit 1 for forming a paper or board web 10,

- a press unit 2,
- a dryer unit 3 which applies single-wire draw,
- a calendering unit 4,
- a first after-dryer unit 5, i.e. located after calendering, which applies twin-wire draw,

5

and the paper machine shown in Fig. 1 additionally includes as finishing equipment:

- a coating unit 6 which can be bypassed in the run illustrated in the figure,
- a second after-dryer unit 7, i.e. located after the coating unit 6, which unit applies twin-wire draw, and

10

- a reeling unit 8.

15

[0035] As seen from Fig. 1, the dryer unit 3 and both after-dryer units 5 and 7 are provided with an air impingement arrangement 20 disposed in connection with and on top of the last drying cylinder of each of said units in accordance with the invention. An impingement blowing is directed against the web 10 by means of the air impingement arrangement in order to compensate for any curl of the web. The air impingement arrangement 20 extends substantially across the entire width of the web 10 running in the vicinity of, i.e. by and under said arrangement, forming with the web 10 a zone for contact-free treatment of the web with air, in which zone the cold air used for treatment of the web is most advantageously:

20

- hall air
- cooled hall air or
- moistened hall air

from the machinery hall surrounding the paper or board machine.

25

[0036] In accordance with the invention, the impingement applied to the web 10 from the impingement arrangement 20 is thus constituted by a hot blowing and a cold blowing with air, said blowings following one after the other. In that connection, with the moisture which condenses and/or is absorbed into the web in cold air blowing, the curl behaviour of the web changes to the range of structural, i.e. reversible curl behaviour. In order to assure that moisture is condensed and/or

absorbed into the web, it is advantageous that the temperature of the cold air blowing is substantially lower than the temperature of the hot air blowing and/or the temperature of the web 10 running under the air treatment zone. Most commonly, the temperature of the hall air used in cold air blowing is below 30 °C, but the air may be heated in blowers by 15-20 °C. Despite this heating, the cold air which is blown is substantially colder than the temperature of 90-120 °C of the web and/or the surroundings around it at the downstream end of the dryer unit. Advantageously, the temperature of cold air blowing is below 50 °C. When hot and cold air meet each other, the moisture present in the air condenses, being then enabled to pass into the web with the flow of air and to be absorbed into it and/or to condense in it.

[0037] Fig. 1 illustrates two advantageous ways to arrange air impingement in accordance with the invention in a drying zone. Thus, as shown in Fig. 1, air impingement can be directed so as to act either on the top surface of a drying wire 9 located on the web 10 placed against a drying cylinder, in which connection the air impingement arrangement 20 is disposed inside a drying wire loop. This kind of embodiment is illustrated in connection with the dryer unit 3 and the second after-dryer unit 7. Alternatively, air impingement can also be arranged to act directly on the free surface of the web 10 which is free on a drying cylinder, in which connection the air impingement arrangement 20 is located outside a drying wire loop, and the drying wire loop is separated from the web before the air impingement arrangement. This kind of embodiment is illustrated in connection with the first after-dryer unit **[6]5**.

[0038] In accordance with the embodiments of the invention considered to be advantageous, the air impingement arrangement 20; 20a, 20b, by means of which the web 10 is first subjected to a hot blowing and then to a cold blowing with air, comprises:

- one hood 20 placed on top of a drying cylinder 23, a suction roll or an air impingement roll, the hood being divided by an internal partition wall 27 into a hot air blowing part 21 and a cold air blowing part 22 (cf. FIG. 2 and FIG. 3),

- two separate hoods 20a and 20b placed on top of successive drying cylinders 23, suction rolls 28 and/or air impingement rolls, the first of the hoods being a hot air blowing part 21 and the second being a cold air blowing part 22 (cf. FIG. 4 and FIG. 5), or
- 5 - one hood 20a, placed on top of a drying cylinder 23, a suction roll 28 or an air impingement roll, the hood functioning as a hot air blowing part 21, and a blow box or an airborne drying unit 20b disposed after it and acting on the web, the blow box or the airborne drying unit functioning as a cold air blowing part 22 (cf. FIG. 6 and FIG. 7).

10 **[0039]** In the first embodiment of the air impingement arrangement according to the invention shown in Fig. 2, the air impingement arrangement 20 is located inside a drying wire loop and extends across the entire width of the web 10 running under the drying wire 9 in the vicinity thereof, and forms with it a contact-free zone for treatment of the web with air, in which a hot air blowing and a cold air blowing are used for treating the web by impingement, in which the cold air used is advantageously

- hall air,
- cooled hall air, or
- moistened hall air

20 from the machinery hall surrounding the paper or board machine.

15 **[0040]** In accordance with the invention, the hot air blowing and the cold air blowing in the air impingement directed at the web 10 in the air treatment zone follow one after the other, in which connection the cold air blowing makes it possible to:

- cool the web 10, whereby the temperature differences in the web are equalized,
- relax stresses arising in drying, and
- moisten the web 10 by condensing and/or absorbing moisture into it, thus bringing the web 10 to the range of its structural, or reversible, curl behaviour (cf. FIG. 8).

[0041] In the first advantageous embodiment of the air impingement arrangement according to the invention as shown in Fig. 2, the air impingement arrangement includes one hood 20, advantageously disposed in connection with the last drying cylinder 23 of the dryer unit 3, 5, 7 on top of the drying cylinder 23.

5 **[0042]** In order to produce a hot air blowing and a cold air blowing, the hood 20 is divided by the partition wall 27 into two sections, of which the first section in the machine direction is the hot air blowing part 21 and the second section is the cold air blowing part 22. In that connection, in the machine direction, the web 10 is first subjected to a blowing with hot air from the hood 20 and after that to a blowing with 10 cold air. In this kind of air impingement arrangement implemented with one hood, the zone for treatment of the web with air is bipartite and comprises a first and a second area defined by the bipartite hood 20 at it and extending across the width of the web 10.

15 **[0043]** Fig. 2 illustrates with a broken line one advantageous further application in order to enhance the cooling of the web. In this further application, after the cold blowing part 22 of the air impingement arrangement 20, the web 10 is passed on support of an additional cooling wire 26 against the circumferential surface of an additional cooling cylinder 25. In that connection, it is thus possible to further cool 20 the web 10 in order that it may be calendered as cold as possible. It must be emphasized that this additional feature is not most essential from the point of view of the present invention, but it is described here as a possibility enhancing the cooling effect produced by the cold blowing according to the invention.

25 **[0044]** In accordance with one embodiment of the invention considered advantageous, the drying cylinder 23, the suction roll 28 or the air impingement roll can also be a cooling cylinder known in itself in the state of the art, whereby a cooling effect can be directed at the web 10 from both sides thereof.

[0045] The alternative embodiment of the first advantageous embodiment of the

invention shown in Fig. 3 differs from the first advantageous embodiment of the invention shown in Fig. 2 in that

- in the place of the drying cylinder 23, there is a suction roll 28 or an air impingement roll, the [suction]roll 28 may be either a suction roll marketed by the applicant under the trademark VAC-roll™, in which roll vacuum is effective on the entire inner surface of the roll (cf. FIG. 3 and FIG 5), or a conventional suction roll provided with a suction zone (cf. FIG. 7), and
- at the air impingement arrangement, as a drying wire there is a drying wire 9' located underneath the web 10.

In that connection, the drying wire 9 meandering with the web 10 in the dryer unit 3, 5, 7 has been arranged to separate from the web 10 before the air impingement arrangement, and in the air impingement arrangement both hot air blowing and cold air blowing take place from above directly and immediately against the free top surface of the web 10. In this way, cooling, relaxation of stresses and equalization of temperature differences are even more effective than in the embodiment shown in Fig. 2, in which hot air and cold air blowings take place through or by means of the drying wire 9 against the web 10.

[0046] In the second embodiment of the air impingement arrangement according to the invention shown in Fig. 4, the bipartite air impingement arrangement 20a, 20b is located inside a drying wire loop and extends across the entire width of the web 10 running under the drying wire 9 in the vicinity thereof, and forms with it a contact-free zone for treatment of the web with air, in which a hot air blowing and a cold air blowing are used for treating the web by impingement, in which connection the cold air is advantageously

- hall air,
- cooled hall air, or
- moistened hall air

from the machinery hall surrounding the paper or board machine.

In accordance with the invention, the hot air blowing and the cold air blowing in the air impingement directed at the web 10 in the air treatment zone follow separately

one after the other, in which connection the cold air blowing makes it possible to:

- cool the web 10, whereby the temperature differences in the web are equalized,
- relax stresses arising in drying, and
- moisten the web 10 by condensing and/or absorbing moisture into it, thus bringing the web 10 to the range of its structural, or reversible, curl behaviour (cf. FIG. 8).

5

[0047] In the second advantageous embodiment of the air impingement arrangement 20a, 20b according to the invention shown in Fig. 4, the air impingement arrangement includes two hoods, advantageously disposed in connection with the last two drying cylinders 23 of the dryer unit 3, 5, 7 on top of the drying cylinders 23. In order to produce a hot air blowing and a cold air blowing, the first hood 20a in the machine direction constitutes a hot blowing part 21 and the second hood 20b constitutes a cold blowing part 22 of the air impingement arrangement. In other words, in that connection, in the machine direction, the web 10 is subjected to a blowing with hot air from the first hood 20a and after that to a blowing with cold air from the second hood 20b. In this kind of air impingement arrangement accomplished by means of two separate hoods 20a, 20b, the web treatment zone is bipartite and comprises separate first and second areas defined by the hoods 20a and 20b at said hoods and extending across the width of the web 10.

10

[0048] In accordance with one embodiment of the invention regarded as advantageous, the drying cylinder 23, the suction roll 28 or the air impingement roll may also be a cooling cylinder known in itself in the state of the art, in which connection a cooling effect can be applied to the web 10 from both sides thereof.

15

[0049] The alternative embodiment of the second advantageous embodiment of the invention shown in Fig. 5 differs from the second alternative advantageous embodiment of the invention shown in Fig. 4 in that

- in the place of the drying cylinders 23, there are suction rolls 28 and/or air impingement rolls, and

- at the air impingement arrangement, as a drying wire there is a drying wire 9 located underneath the web 10.

In that connection, the drying wire 9 meandering with the web 10 in the dryer unit 3, 5, 7 has been arranged to separate from the web 10 before the air impingement

5 arrangement, and in the air impingement arrangement both hot air blowing and cold air blowing take place from above directly and immediately against the free top surface of the web 10. In this way, cooling, relaxation of stresses and equalization of temperature differences are even more effective than in the embodiment shown in Fig. 2, in which hot air and cold air blowings take place through or by means of the 10 drying wire 9 against the web 10.

[0050] In the third embodiment of the air impingement arrangement according to the invention shown in Fig. 6, the bipartite air impingement arrangement 20a, 20b is located inside a drying wire loop and extends across the entire width of the web 10 running under the drying wire 9 in the vicinity thereof, and forms with it a contact-free zone for treatment of the web with air, in which a hot air blowing and a cold air blowing are used for treating the web by impingement, in which connection the cold air is advantageously

15

- hall air,
- cooled hall air, or
- moistened hall air

20 from the machinery hall surrounding the paper or board machine.

In accordance with the invention, the hot air blowing and the cold air blowing in the air impingement directed at the web 10 in the air treatment zone follow separately one after the other, in which connection the cold air blowing makes it possible to:

25

- cool the web 10, whereby the temperature differences in the web are equalized,
- relax stresses arising in drying, and
- moisten the web 10 by condensing and/or absorbing moisture into it, thus bringing the web 10 to the range of its structural, or reversible, curl behaviour (cf. FIG. 8).

5 [0051] The air impingement arrangement 20a, 20b according to the third advantageous embodiment of the invention shown in Fig. 6 includes a hood 20b, advantageously placed in connection with the last two drying cylinders 23 of the dryer unit 3, 5, 7 on top of the dryer cylinders 23, and a blow box or an airborne drying unit 20b extending across the web 10 and blowing cold air against the web.

10 [0052] In order to provide a hot air blowing and a cold air blowing in the machine direction, the hood 20a constitutes the hot air blowing part 21 of the air impingement arrangement and the blow box or the airborne drying unit 20b constitutes the cold air blowing part 22 of the air impingement arrangement. In other words, in that connection, in the machine direction, the web 10 is subjected to a blowing with hot air from the hood 20a and after that to a blowing with cold air from the second blow box or the airborne drying unit 20b. In this kind of air impingement arrangement accomplished by means of a hood 20a and a blow box or an airborne drying unit 20b which are separate from each other, the web treatment zone is bipartite and 15 comprises separate first and second areas which extend across the width of the web 10 and are defined by the hood 20a and the blow box or the airborne drying unit 20b at the hood and at the blow box or the airborne drying unit.

20 [0053] In accordance with one embodiment of the invention regarded as advantageous, the drying cylinder 23, the suction roll 28 or the air impingement roll may also be a cooling cylinder known in itself in the state of the art, in which connection a cooling effect can be applied to the web 10 from both sides thereof.

25 [0054] The alternative embodiment of the third advantageous embodiment of the invention shown in Fig. 7 differs from the third advantageous embodiment of the invention shown in Fig. 6 in that

- in the place of the drying cylinders 23, there is a suction roll 28 or an air impingement roll, and
- at the air impingement arrangement, as a drying wire there is a drying wire 9' located underneath the web 10.

[0055] In that connection, the drying wire 9 meandering with the web 10 in the dryer unit 3, 5, 7 has been arranged to separate from the web 10 before the air impingement arrangement, and in the air impingement arrangement both hot air blowing and cold air blowing take place from above directly and immediately against the free top surface of the web 10. In this way, cooling, relaxation of stresses and equalization of temperature differences are even more effective than in the embodiment shown in Fig. 2, in which hot air and cold air blowings take place through or by means of the drying wire 9 against the web 10.

[0056] Fig. 8 illustrates the effect of the drying operations applied to paper on the curl of paper. The behaviour of paper has been changed by means of drying stresses with respect to its structural curl. In the figure, the structural curl of paper is shown by the upper line of dots and dashes and its range is reached:

- by drying the paper from an initial state in which the curl = 1 CD curl/m and the moisture content = 7.2 % to a predried state in which the curl = 3.3 CD curl/m and the moisture content = 3.5 %, and then
- allowing the paper to be moistened from the predried state to the initial state of structural curl behaviour in which the curl = 2.5 CD curl/m and the moisture content = 7.2 %.
- After that, in spite of drying or rewetting of the paper, the curl of the paper is predictable and remains in the range of reversible structural curl behaviour.

This relaxation of drying stresses according to the invention make it possible to assure that the stresses are in balance such that at final moisture the paper is already at the curve of structural curl and moisture shown in Fig. [5]8, and unpredictable curl of the paper does not cause any problems in the finishing or subsequent utilization of the paper.

[0057] Above, the invention has been described only by means of some of its embodiments regarded as advantageous and by means of some of their alternative embodiments. This is naturally not intended to limit the invention so as to relate only

to this kind of single embodiments. Thus, as is clear to a person skilled in the art, many variations and alternative solutions are feasible within the inventive idea and within the scope of protection defined in the accompanying claims.

Claims

(Note: Amended claims are found in the Preliminary Amendment filed simultaneously herewith.)

10/009095

JC10 Rec'd PCT/PTO 08 NOV 2001

In The United States Patent And Trademark Office

Applicant: Pasi Ahonen, et al.

Date: November 8, 2001

Date Filed: Simultaneously herewith

Docket No.: FORSAL-27

PCT App. No.: PCT/FI00/00410

5 For: Method and Arrangement of Impingement for Blowing Compensation of a Tendency of Curling of a Paper Board Web to be Treated as Well as a Paper or Board Machine

Certificate of Express Mailing

I hereby certify that this document is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 35 C.F.R. §1.10
on 8 November 2001
with Mailing Label No. EV 015 203645 US
and is addressed to the Assistant Commissioner for Patents,
Washington, D.C. 20231.

David R. J. Stiennon

Signature

David R. J. Stiennon, Reg. No. 33212

Name of applicant, assignee or Registered Representative

Clean Copy of Substitute Specification under 37 C.F.R. 1.125(c)

TITLE OF THE INVENTION

Method and Arrangement of Impingement

for Blowing Compensation of a Tendency of Curling of a Paper Board Web

10 to be Treated as Well as a Paper or Board Machine

CROSS REFERENCES TO RELATED APPLICATIONS

[0001] This application is a national stage application of PCT Application No.

10/009095

JC10 Recd/PCT/PTC 08 NOV 2001

In The United States Patent And Trademark Office

Applicant: Pasi Ahonen, et al. Date: November 8, 2001
Date Filed: Simultaneously herewith Docket No.: FORSAL-27
PCT App. No.: PCT/FI00/00410

For: Method and Arrangement of Impingement for Blowing Compensation of a Tendency of Curling of a Paper Board Web to be Treated as Well as a Paper or Board Machine

Certificate of Express Mailing

I hereby certify that this document is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 35 C.F.R. §1.10

on 11/8/01

with Mailing Label No. EV015203645VS

and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

David R. J. Stiennon

Signature

David R. J. Stiennon, Reg. No. 33212

Name of applicant, assignee or Registered Representative

Marked Up Copy of Substitute Specification under 37 C.F.R. 1.125(b)(2)

Deletions are shown with the following attributes and color:

Bold, (No color code).

Deleted text is shown as full text.

Deletions are surrounded by brackets [].

Insertions are shown with the following attributes and color:

Bold, Underline, (No color code).

TITLE OF THE INVENTION

Method and **[a]**Arrangement of **[i]**Impingement

for **[b]**Blowing **[c]**Compensation [

] of a **[t]**Tendency of **[C]**urling of a **[p]**Paper **[b]**Board **[w]**Web

5 to be **[t]**Treated as **[w]**Well as [

]a **[p]**Paper or **[b]**Board **[machine]**

JMachine

CROSS REFERENCES TO RELATED APPLICATIONS

[0001] This application is a national stage application of PCT Application No. PCT/FI00/00410, filed May 9, 2000, and claims priority on Finnish Application No. 991079, filed May 10, 1999, the disclosures of both of which applications are incorporated by reference herein.

5

**STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER
FEDERALLY SPONSORED RESEARCH AND DEVELOPMENT**

Not applicable.

10

BACKGROUND OF THE INVENTION

15

[0002] The present invention relates to paper [or board machines. More specifically, the present invention relates to an air impingement arrangement according to the preamble of claim 1 and to an]and board machine air impingement [method according to the preamble of claim 16 as well as to a paper or board machine according to the preamble of claim 25]methods and apparatus for compensating for the curling tendency of a paper or board web[to be treated].

20

[0003] As known in the prior art, multi-cylinder dryer units of a paper machine employ twin-wire draw and/or single-wire draw. In twin-wire draw, the drying cylinder groups comprise two wires which press the web one from above and the other from below against heated cylinder surfaces. Between the drying cylinder rows, generally horizontal rows, there are free and unsupported draws, in which connection the web is susceptible to fluttering, which may cause web breaks, especially when the web is still moist and therefore weak. For this reason, single wire draw has recently been adopted and applied in the dryer unit in practice without an exception, each drying cylinder group of the single wire draw including only one drying wire, on support of which the web runs through the entire group such that, on

25

the [~~crying~~]**drying** cylinders, the drying wire presses the web against heated cylinder surfaces, and on the reversing cylinders or rolls between the drying cylinders, the web runs on the outer surface of the drying wire. Typically, the dryer unit of a paper machine comprises 20-30 drying cylinders and reversing cylinders, in which connection a multi-cylinder dryer has 5-8 wire groups and the groups located at the upstream end of the dryer unit are normally shorter than the groups at the downstream end thereof.

[0004] In so-called normal single-wire draw groups of the prior art, the heated drying cylinders are located in an upper row and the reversing cylinders are located in lower rows, which rows are commonly horizontal and parallel to one another. The applicant's *FI patent 54627* (corresponding *US patent 4,202,113*) proposes placing successively above-mentioned normal single-wire groups and so-called inverted single-wire groups, in which heated drying cylinders are located in a lower row and reversing suction cylinders or rolls are located in an upper row with the main purpose of drying the web symmetrically on both sides thereof. Beloit Corp. have also put forward some proposals for dryer units comprising normal and inverted cylinder groups, in respect of which reference is made to international application publications *WO 88/06204* and *WO 88/06205* and to *US patent 4,934,067*, which proposes inverted groups for a dryer unit for control of curl. According to *US patent 5,269,074* (Beloit Corp.), a long dryer unit applying single-wire draw is followed by a short dryer unit applying twin-wire draw with the purpose of controlling curl of the web.

[0005] The use of moist steam for straightening curl has already been known in the art since the 1970's and the 1980's, as appears in *US patent 3,948,721* (Vinheim Karl) or in *US patent 5,557,860* (Voith) and in public *FI patent application 821431*, which teaches passing the web through a steam treatment station in order to straighten curl. Recently, dryer units provided with single-wire draw have become common in which the upper or lower cylinders are steam-heated drying cylinders, the web coming into direct contact with said cylinders while being pressed by the

drying wire, and in which the lower or upper cylinders are cylinders provided with internal suction, for example, [the applicant's] **Metso Paper, Inc.**'s so-called **VAC-ROLL™** cylinders in which a vacuum effect is directed through the perforated shell of the cylinders from the interior space of the reversing cylinder to the grooves extending around the shell of the cylinder. Said vacuum effect serves to maintain the web in contact with the drying wire when the web comes to the side of the outside curve on the reversing cylinders. At the same time, the transverse shrinkage of the web is sought to be prevented while drying progresses.

[0006] In paper and board machines, the reeling of the web is usually sought to be carried out when the web is as cold as possible, and in order to achieve this aim, it is prior known that a cooling cylinder is used at the end of the dryer unit. In accordance with the commonly known state of the art, the cooling of the web has the following effects:

- the relaxation time of the web can be shortened, which leads to smaller differences of stress in the web before the next process stage (e.g. calendering or reeling) as compared with a situation that the web is passed forwards at a higher temperature,
- the temperature differences themselves can be reduced by lowering temperature level, which leads to smaller differences in the elastic-plastic behaviour of the web in the next process stage or before it.

[0007] The most substantial problem associated with single-wire draw is that drying heating is directed, i.e. by convection from the surface of a heated drying cylinder, more intensely only at one surface of the web from one direction. As a result of this one-direction heating, there arises a strong tendency to curl in the web. This problem is also previously known and in order to deal with it, several different solutions have been proposed in the course of years. However, it is common to all these solutions that there remain in the web more or less internal stresses which will release in an unpredictable manner at a later stage and may cause problems as soon

as in connection with finishing, such as coating and reeling, or later at the stage at which the paper product is utilized.

[0008] With respect to this complex of problems and the prior art associated with the background of the invention, reference is further made to the publications

5 **[0009] FI 902616[**

]describes a steam box disposed in a dryer unit for relaxation of drying stresses and thus for compensating for curl.

[0010] FI 931263[

10]describes air impingement against a large cylinder which has a diameter > 2 m and which is placed inside a drying wire loop. Said publication proposes the division of air impingement into sections, in which connection each section uses hot air or superheated steam having a temperature, moisture and/or pressure which is different in each section in order to prevent transverse shrinkage of the web, to control drying of the web and to achieve a desired moisture profile for the web.

15 **[0011] FI 950434[**

20]proposes passing a web, which has a tendency to curl because of the nonsymmetrical forward-drying of the bottom and top surfaces of the web, to finishing in which the tendencies to curl are compensated for by moistening and/or plastically working the web.

[0012] FI 951748[

]describes a dryer unit which applies single-wire draw for control of curl and in which the last group is inverted to allow drying on both sides.

[0013] FI 963734[

25]proposes an arrangement for drying a coated paper web in a drying group

of an after-dryer unit applying single-wire draw, the web being treated in said arrangement after that by means of a steam box in order to compensate for the tendency to curl.

[0014] FI 964830[

5]proposes an arrangement for compensating for the curling tendency of a paper web by means of an air impingement device which is placed above a drying cylinder and by which hot moist air is blown against the web.

[0015] FI 971301[

10]discloses an arrangement for controlling the curl of a paper web by means of a dryer unit. According to said arrangement, the necessary operations are carried out in several stages while the temperature of the web is below 85 °C. According to the publication, the curl control treatment is accomplished by means of a steam box or a moistening device.

[0016] FI 971713[

15]proposes arranging a large-diameter air impingement drying cylinder in connection with a dryer unit which applies single-wire draw and has drying cylinders placed below and reversing cylinders placed above, which air impingement drying cylinder is placed inside a drying wire loop and on top or in the vicinity of which cylinder, at both sides, heated smaller-diameter cylinders are placed, whereby, when the web is supported by the drying wire over the entire length of the dryer unit, uneven transverse shrinkage of the web can be prevented and avoided.

[0017] FI 972080[

25]proposes disposing a steam box and/or a moistening device and/or an infrared dryer after a calender or, if calendering is not employed, in connection with a machine reel or in connection with the finishing process

after it in order to compensate for curl of a web.

[0018] Despite numerous approaches of the prior art, it has not been possible to eliminate the curl of the web in paper or board machines and, recently, with increasing running speeds, the curling tendency has been also increased by the more and more common demand for downwardly open dryer units applying single-wire draw to be disposed in paper or board machines in order that the paper or board machine might be placed in a smaller, i.e. lower hall space and that, at the same time, the serviceability of the dryer unit might be improved and the contamination problems kept small. Indeed, a substantial problem with the manufacture of paper and board is still that the control of the profileability of the web is slow, and different elongation streaks, waves or curls arise because of drying stresses, and that paper or board subjected to unequal-sided drying, in particular thin paper grades, such as different directory papers, exhibits very intense wave formation and curl when they come into contact with the moisture of air after the manufacturing process.

SUMMARY OF THE INVENTION

[0019] The primary object of the present invention is to improve compensation for the curling tendency of a paper or board web and attempt to minimize drying stresses arising in the web and to bring the curling tendency of the web to the range of reversible, or structural curl behaviour, in which connection the web is as free as possible from stresses and cooled for being wound as cold as possible. One further object of the invention is also to make control of the profileability of the web quicker and to increase drying capacity in connection with single-wire draws.

[This primary object of the present invention is achieved by means of an air impingement arrangement of the kind mentioned at the beginning, the special features characteristic of said arrangement being set forth in the independent claim 1 of the accompanying set of claims, by means of an air impingement method, the special features characteristic of said method being set forth in the

independent claim 16 of the accompanying set of claims, and by means of a paper or board machine, the special features characteristic of said machine being set forth in the independent claim 25 of the accompanying set of claims.

[0020] Thus, the invention is based on a new and inventive basic idea that, in order to minimize the drying stresses of a web, in at least one zone in which the web is treated with air and which extends substantially across the entire width of the web, air impingement directed at the web includes, one following after the other, at least one hot air blowing and at least one cold air blowing in which the cold air used is hall air from the machinery hall surrounding the paper or board machine, cooled hall air and/or moistened hall air. The moisture of such hall air condenses when the air comes into an environment which is warmer than the air, with the result that the web in cold air impingement is not only cooled but also moistened by the action of the blowing air because condensed moisture is condensed and/or absorbed into the web, in which connection the curl behaviour of the web changes with moisture to the range of structural, i.e. reversible curl behaviour, which is conducive to substantially compensating for the curling tendency of paper or board.

[0021] In accordance with the invention, it is advantageous that an air impingement arrangement is arranged in a hood which is located above a drying cylinder, a suction roll or an air-impingement roll, which is advantageously the last drying cylinder, suction roll or air-impingement roll of a dryer unit, and which hood is divided with a partition wall into two sections, in which connection the web is subjected in the machine direction first to a blowing with hot air and after that to a blowing with cold air. In that connection, the air treatment zone of the web comprises a first and a second area which are defined by the bipartite hood at said hood and which extend across the width of the web. In that connection, depending on the drying wire loop arrangement, air impingement can be applied either directly to the free surface of the web or to the free surface of the drying wire located on the web. As an alternative to a bipartite hood, the air impingement arrangement can comprise in accordance with the invention

- Two successive hoods placed on top of two successive drying cylinders, suction rolls and/or air impingement rolls, in which connection the former hood in the machine direction is advantageously located in connection with the second last drying cylinder, suction roll or air impingement roll and blows hot air against the web and the latter hood in the machine direction is advantageously located in connection with the last drying cylinder, suction roll or air impingement roll and blows cold air against the web. In that connection, the zone for air treatment of the web is bipartite and comprises separately a first area extending across the width of the web and located at the hood blowing hot air and a second area extending across the width of the web and located at the hood blowing cold air;
- A hood arranged in connection with a drying cylinder, a suction roll or an air impingement roll, which is advantageously the last drying cylinder, suction roll or air impingement roll of a dryer unit, which hood blows hot air against the web, and a blow box or an airborne drying unit extending across the web and blowing cold air against the web. In that connection, the zone for air treatment of the web is bipartite and comprises separately a first area extending across the width of the web and located at the hood blowing hot air and a second area extending across the width of the web and located at the blow box or the airborne drying unit blowing cold air.

20 **[0022]** In accordance with the embodiments of the invention regarded as preferable, it is advantageous that the temperature of the cold air blowing is $\leq 50^{\circ}\text{C}$. For the purpose of cooling the web further before its further treatment, a cooling cylinder can be arranged to cool the web after the air treatment zone.

25 **[0023]** With respect to the benefits of the invention, it may be mentioned that

- balanced drying can be achieved which minimizes the drying stresses arising in paper,
- cooling of the web before calendering equalizes the temperature differences and temperature profiles appearing in it,
- cooling has been found to generally have a favourable effect on the relaxation of

the web,

- when drying takes place by air impingement, crystallization of lignin caused by single-wire draw cylinders can be avoided and final drying can be carried out at low temperatures,
- 5 - the drying capacity of single-wire draw increases substantially, even by 10-15 %,
- control of drying and cooling is quick and therefore the web can be profiled quickly,
- when cooling cold air blowing is coupled with hot air blowing, energy can be saved,
- 10 - air impingement according to the invention can be applied both in a forward-dryer section and in an after-dryer section,
- because of the downwardly open structure, the air impingement arrangement according to the invention makes it possible in a paper or board machine that removal of broke and cleaning of the unit can be carried out directly from machine level and from below the hood,
- 15 - when single-wire draw is provided simultaneously with the air impingement arrangement according to the invention, blowers and other auxiliary devices can be placed on the lower level which becomes free or, especially in connection with new machines, the basement space can be left unbuilt altogether in the area of cylinder drying,
- when compared with the cooling of the web accomplished by means of cooling cylinders and on the water-jet principle, the air impingement arrangement according to the invention is
 - clean because no drip water problem is encountered in the invention,
 - 25 advantageous because no displacements of cylinders and a reel are needed, and it also
 - requires little space, is economical in terms of energy and easy to operate,
 - the air impingement according to the invention is suitable for use both in on- and off-machine dryer sections and calenders, and can also be located in the middle of a dryer section, for example, in on-machine calendering and in intermediate calendering, and
- 30

- it can be applied both to coated and to uncoated papers and boards.

[0024] With respect to other special features of the invention and to the advantages attainable by them, reference is made to the dependent claims of the accompanying set of claims.

5

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The invention will be described below with reference to the accompanying drawing in which

[0026] FIG. 1 shows generally a paper or board machine which is provided with an air impingement arrangement in accordance with a first advantageous embodiment of the invention,

[0027] FIG. 2 shows the air impingement arrangement in accordance with the first advantageous embodiment of the invention in more detail,

[0028] FIG. 3 shows an alternative air impingement arrangement of the first advantageous embodiment of the invention,

[0029] FIG. 4 shows an air impingement arrangement in accordance with a second embodiment of the invention regarded as advantageous,

[0030] FIG. 5 shows an alternative air impingement arrangement of the second advantageous embodiment of the invention,

[0031] FIG. 6 shows an air impingement arrangement in accordance with a third embodiment of the invention regarded as advantageous,

[0032] FIG. 7 shows an alternative air impingement arrangement of the third advantageous embodiment of the invention, and

[0033] FIG. 8 illustrates the change of curling tendency as a function of moisture content in connection with air impingement in accordance with the invention.

25

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0034] Fig.1 shows an LWC paper machine which includes:

- a unit 1 for forming a paper or board web 10,

- a press unit 2,
- a dryer unit 3 which applies single-wire draw,
- a calendering unit 4,
- a first after-dryer unit 5, i.e. located after calendering, which applies twin-wire draw,

5

and the paper machine shown in Fig. 1 additionally includes as finishing equipment:

- a coating unit 6 which can be bypassed in the run illustrated in the figure,
- a second after-dryer unit 7, i.e. located after the coating unit 6, which unit applies twin-wire draw, and

10

- a reeling unit 8.

[0035] As seen from Fig. 1, the dryer unit 3 and both after-dryer units 5 and 7 are provided with an air impingement arrangement 20 disposed in connection with and on top of the last drying cylinder of each of said units in accordance with the invention. An impingement blowing is directed against the web 10 by means of the air impingement arrangement in order to compensate for any curl of the web. The air impingement arrangement 20 extends substantially across the entire width of the web 10 running in the vicinity of, i.e. by and under said arrangement, forming with the web 10 a zone for contact-free treatment of the web with air, in which zone the cold air used for treatment of the web is most advantageously:

15

- hall air
- cooled hall air or
- moistened hall air

20 from the machinery hall surrounding the paper or board machine.

25

[0036] In accordance with the invention, the impingement applied to the web 10 from the impingement arrangement 20 is thus constituted by a hot blowing and a cold blowing with air, said blowings following one after the other. In that connection, with the moisture which condenses and/or is absorbed into the web in cold air blowing, the curl behaviour of the web changes to the range of structural, i.e. reversible curl behaviour. In order to assure that moisture is condensed and/or

absorbed into the web, it is advantageous that the temperature of the cold air blowing is substantially lower than the temperature of the hot air blowing and/or the temperature of the web 10 running under the air treatment zone. Most commonly, the temperature of the hall air used in cold air blowing is below 30 °C, but the air may be heated in blowers by 15-20 °C. Despite this heating, the cold air which is blown is substantially colder than the temperature of 90-120 °C of the web and/or the surroundings around it at the downstream end of the dryer unit. Advantageously, the temperature of cold air blowing is below 50 °C. When hot and cold air meet each other, the moisture present in the air condenses, being then enabled to pass into the web with the flow of air and to be absorbed into it and/or to condense in it.

[0037] Fig. 1 illustrates two advantageous ways to arrange air impingement in accordance with the invention in a drying zone. Thus, as shown in Fig. 1, air impingement can be directed so as to act either on the top surface of a drying wire 9 located on the web 10 placed against a drying cylinder, in which connection the air impingement arrangement 20 is disposed inside a drying wire loop. This kind of embodiment is illustrated in connection with the dryer unit 3 and the second after-dryer unit 7. Alternatively, air impingement can also be arranged to act directly on the free surface of the web 10 which is free on a drying cylinder, in which connection the air impingement arrangement 20 is located outside a drying wire loop, and the drying wire loop is separated from the web before the air impingement arrangement. This kind of embodiment is illustrated in connection with the first after-dryer unit **[6]5**.

[0038] In accordance with the embodiments of the invention considered to be advantageous, the air impingement arrangement 20; 20a, 20b, by means of which the web 10 is first subjected to a hot blowing and then to a cold blowing with air, comprises:

- one hood 20 placed on top of a drying cylinder 23, a suction roll or an air impingement roll, the hood being divided by an internal partition wall 27 into a hot air blowing part 21 and a cold air blowing part 22 (cf. FIG. 2 and FIG. 3),

- two separate hoods 20a and 20b placed on top of successive drying cylinders 23, suction rolls 28 and/or air impingement rolls, the first of the hoods being a hot air blowing part 21 and the second being a cold air blowing part 22 (cf. FIG. 4 and FIG. 5), or

5 - one hood 20a, placed on top of a drying cylinder 23, a suction roll 28 or an air impingement roll, the hood functioning as a hot air blowing part 21, and a blow box or an airborne drying unit 20b disposed after it and acting on the web, the blow box or the airborne drying unit functioning as a cold air blowing part 22 (cf. FIG. 6 and FIG. 7).

10 **[0039]** In the first embodiment of the air impingement arrangement according to the invention shown in Fig. 2, the air impingement arrangement 20 is located inside a drying wire loop and extends across the entire width of the web 10 running under the drying wire 9 in the vicinity thereof, and forms with it a contact-free zone for treatment of the web with air, in which a hot air blowing and a cold air blowing are used for treating the web by impingement, in which the cold air used is advantageously

- hall air,
- cooled hall air, or
- moistened hall air

15 from the machinery hall surrounding the paper or board machine.

20 **[0040]** In accordance with the invention, the hot air blowing and the cold air blowing in the air impingement directed at the web 10 in the air treatment zone follow one after the other, in which connection the cold air blowing makes it possible to:

- cool the web 10, whereby the temperature differences in the web are equalized,
- relax stresses arising in drying, and
- moisten the web 10 by condensing and/or absorbing moisture into it, thus bringing the web 10 to the range of its structural, or reversible, curl behaviour (cf. FIG. 8).

[0041] In the first advantageous embodiment of the air impingement arrangement according to the invention as shown in Fig. 2, the air impingement arrangement includes one hood 20, advantageously disposed in connection with the last drying cylinder 23 of the dryer unit 3, 5, 7 on top of the drying cylinder 23.

5 **[0042]** In order to produce a hot air blowing and a cold air blowing, the hood 20 is divided by the partition wall 27 into two sections, of which the first section in the machine direction is the hot air blowing part 21 and the second section is the cold air blowing part 22. In that connection, in the machine direction, the web 10 is first subjected to a blowing with hot air from the hood 20 and after that to a blowing with 10 cold air. In this kind of air impingement arrangement implemented with one hood, the zone for treatment of the web with air is bipartite and comprises a first and a second area defined by the bipartite hood 20 at it and extending across the width of the web 10.

15 **[0043]** Fig. 2 illustrates with a broken line one advantageous further application in order to enhance the cooling of the web. In this further application, after the cold blowing part 22 of the air impingement arrangement 20, the web 10 is passed on support of an additional cooling wire 26 against the circumferential surface of an additional cooling cylinder 25. In that connection, it is thus possible to further cool 20 the web 10 in order that it may be calendered as cold as possible. It must be emphasized that this additional feature is not most essential from the point of view of the present invention, but it is described here as a possibility enhancing the cooling effect produced by the cold blowing according to the invention.

25 **[0044]** In accordance with one embodiment of the invention considered advantageous, the drying cylinder 23, the suction roll 28 or the air impingement roll can also be a cooling cylinder known in itself in the state of the art, whereby a cooling effect can be directed at the web 10 from both sides thereof.

[0045] The alternative embodiment of the first advantageous embodiment of the

invention shown in Fig. 3 differs from the first advantageous embodiment of the invention shown in Fig. 2 in that

- in the place of the drying cylinder 23, there is a suction roll 28 or an air impingement roll, the [suction]roll 28 may be either a suction roll marketed by the applicant under the trademark VAC-roll™, in which roll vacuum is effective on the entire inner surface of the roll (cf. FIG. 3 and FIG 5), or a conventional suction roll provided with a suction zone (cf. FIG. 7), and
- at the air impingement arrangement, as a drying wire there is a drying wire 9' located underneath the web 10.

10 In that connection, the drying wire 9 meandering with the web 10 in the dryer unit 3, 5, 7 has been arranged to separate from the web 10 before the air impingement arrangement, and in the air impingement arrangement both hot air blowing and cold air blowing take place from above directly and immediately against the free top 15 surface of the web 10. In this way, cooling, relaxation of stresses and equalization of temperature differences are even more effective than in the embodiment shown in Fig. 2, in which hot air and cold air blowings take place through or by means of the drying wire 9 against the web 10.

20 **[0046]** In the second embodiment of the air impingement arrangement according to the invention shown in Fig. 4, the bipartite air impingement arrangement 20a, 20b is located inside a drying wire loop and extends across the entire width of the web 10 running under the drying wire 9 in the vicinity thereof, and forms with it a contact-free zone for treatment of the web with air, in which a hot air blowing and a cold air blowing are used for treating the web by impingement, in which connection the cold air is advantageously

25

- hall air,
- cooled hall air, or
- moistened hall air

from the machinery hall surrounding the paper or board machine.

30 In accordance with the invention, the hot air blowing and the cold air blowing in the air impingement directed at the web 10 in the air treatment zone follow separately

one after the other, in which connection the cold air blowing makes it possible to:

- cool the web 10, whereby the temperature differences in the web are equalized,
- relax stresses arising in drying, and
- moisten the web 10 by condensing and/or absorbing moisture into it, thus bringing the web 10 to the range of its structural, or reversible, curl behaviour (cf. FIG. 8).

5

[0047] In the second advantageous embodiment of the air impingement arrangement 20a, 20b according to the invention shown in Fig. 4, the air impingement arrangement includes two hoods, advantageously disposed in connection with the last two drying cylinders 23 of the dryer unit 3, 5, 7 on top of the drying cylinders 23. In order to produce a hot air blowing and a cold air blowing, the first hood 20a in the machine direction constitutes a hot blowing part 21 and the second hood 20b constitutes a cold blowing part 22 of the air impingement arrangement. In other words, in that connection, in the machine direction, the web 10 is subjected to a blowing with hot air from the first hood 20a and after that to a blowing with cold air from the second hood 20b. In this kind of air impingement arrangement accomplished by means of two separate hoods 20a, 20b, the web treatment zone is bipartite and comprises separate first and second areas defined by the hoods 20a and 20b at said hoods and extending across the width of the web 10.

10

15

20

[0048] In accordance with one embodiment of the invention regarded as advantageous, the drying cylinder 23, the suction roll 28 or the air impingement roll may also be a cooling cylinder known in itself in the state of the art, in which connection a cooling effect can be applied to the web 10 from both sides thereof.

25

[0049] The alternative embodiment of the second advantageous embodiment of the invention shown in Fig. 5 differs from the second alternative advantageous embodiment of the invention shown in Fig. 4 in that

- in the place of the drying cylinders 23, there are suction rolls 28 and/or air impingement rolls, and

- at the air impingement arrangement, as a drying wire there is a drying wire 9' located underneath the web 10.

In that connection, the drying wire 9 meandering with the web 10 in the dryer unit 3, 5, 7 has been arranged to separate from the web 10 before the air impingement

5 arrangement, and in the air impingement arrangement both hot air blowing and cold air blowing take place from above directly and immediately against the free top surface of the web 10. In this way, cooling, relaxation of stresses and equalization of temperature differences are even more effective than in the embodiment shown in Fig. 2, in which hot air and cold air blowings take place through or by means of the 10 drying wire 9 against the web 10.

[0050] In the third embodiment of the air impingement arrangement according to the invention shown in Fig. 6, the bipartite air impingement arrangement 20a, 20b is located inside a drying wire loop and extends across the entire width of the web 10 running under the drying wire 9 in the vicinity thereof, and forms with it a contact-free zone for treatment of the web with air, in which a hot air blowing and a cold air blowing are used for treating the web by impingement, in which connection the cold air is advantageously

15

- hall air,
- cooled hall air, or
- moistened hall air

20 from the machinery hall surrounding the paper or board machine.

In accordance with the invention, the hot air blowing and the cold air blowing in the air impingement directed at the web 10 in the air treatment zone follow separately one after the other, in which connection the cold air blowing makes it possible to:

25

- cool the web 10, whereby the temperature differences in the web are equalized,
- relax stresses arising in drying, and
- moisten the web 10 by condensing and/or absorbing moisture into it, thus bringing the web 10 to the range of its structural, or reversible, curl behaviour (cf. FIG. 8).

5 **[0051]** The air impingement arrangement 20a, 20b according to the third
advantageous embodiment of the invention shown in Fig. 6 includes a hood 20b,
advantageously placed in connection with the last two drying cylinders 23 of the
dryer unit 3, 5, 7 on top of the dryer cylinders 23, and a blow box or an airborne
drying unit 20b extending across the web 10 and blowing cold air against the web.

10 **[0052]** In order to provide a hot air blowing and a cold air blowing in the machine
direction, the hood 20a constitutes the hot air blowing part 21 of the air impingement
arrangement and the blow box or the airborne drying unit 20b constitutes the cold air
blowing part 22 of the air impingement arrangement. In other words, in that
connection, in the machine direction, the web 10 is subjected to a blowing with hot
air from the hood 20a and after that to a blowing with cold air from the second blow
box or the airborne drying unit 20b. In this kind of air impingement arrangement
accomplished by means of a hood 20a and a blow box or an airborne drying unit 20b
which are separate from each other, the web treatment zone is bipartite and
15 comprises separate first and second areas which extend across the width of the web
10 and are defined by the hood 20a and the blow box or the airborne drying unit 20b
at the hood and at the blow box or the airborne drying unit.

20 **[0053]** In accordance with one embodiment of the invention regarded as
advantageous, the drying cylinder 23, the suction roll 28 or the air impingement roll
may also be a cooling cylinder known in itself in the state of the art, in which
connection a cooling effect can be applied to the web 10 from both sides thereof.

25 **[0054]** The alternative embodiment of the third advantageous embodiment of the
invention shown in Fig. 7 differs from the third advantageous embodiment of the
invention shown in Fig. 6 in that

- in the place of the drying cylinders 23, there is a suction roll 28 or an air
impingement roll, and
- at the air impingement arrangement, as a drying wire there is a drying wire 9'
located underneath the web 10.

[0055] In that connection, the drying wire 9 meandering with the web 10 in the dryer unit 3, 5, 7 has been arranged to separate from the web 10 before the air impingement arrangement, and in the air impingement arrangement both hot air blowing and cold air blowing take place from above directly and immediately against the free top surface of the web 10. In this way, cooling, relaxation of stresses and equalization of temperature differences are even more effective than in the embodiment shown in Fig. 2, in which hot air and cold air blowings take place through or by means of the drying wire 9 against the web 10.

[0056] Fig. 8 illustrates the effect of the drying operations applied to paper on the curl of paper. The behaviour of paper has been changed by means of drying stresses with respect to its structural curl. In the figure, the structural curl of paper is shown by the upper line of dots and dashes and its range is reached:

- by drying the paper from an initial state in which the curl = 1 CD curl/m and the moisture content = 7.2 % to a predried state in which the curl = 3.3 CD curl/m and the moisture content = 3.5 %, and then
- allowing the paper to be moistened from the predried state to the initial state of structural curl behaviour in which the curl = 2.5 CD curl/m and the moisture content = 7.2 %.
- After that, in spite of drying or rewetting of the paper, the curl of the paper is predictable and remains in the range of reversible structural curl behaviour.

This relaxation of drying stresses according to the invention make it possible to assure that the stresses are in balance such that at final moisture the paper is already at the curve of structural curl and moisture shown in Fig. [5]8, and unpredictable curl of the paper does not cause any problems in the finishing or subsequent utilization of the paper.

[0057] Above, the invention has been described only by means of some of its embodiments regarded as advantageous and by means of some of their alternative embodiments. This is naturally not intended to limit the invention so as to relate only

to this kind of single embodiments. Thus, as is clear to a person skilled in the art, many variations and alternative solutions are feasible within the inventive idea and within the scope of protection defined in the accompanying claims.

Claims

(Note: Amended claims are found in the Preliminary Amendment filed simultaneously herewith.)

[57] Abstract

1 ABSTRACT OF THE DISCLOSURE

An air impingement arrangement and method for compensating for the curling tendency of a paper or board web which is being treated. Air impingement is disposed in connection with a paper or board process or with its finishing process and extends across the width of the web (10) running in the vicinity thereof, forming a contact-free web treatment zone, in which process the web is dried in at least one dryer unit (3, 5, 7) that applies single-wire draw. In accordance with the invention, air impingement directed at the web (10) is produced by [means of]the air impingement arrangement (20) in the web treatment zone, said air impingement including, one following after the other, at least one hot blowing with air and at least one cold blowing with air. The invention also relates to a paper or board machine provided with this kind of air impingement arrangement.[

(FIG. 2)

15

1

PCT/FI00/00410, filed May 9, 2000, and claims priority on Finnish Application No. 991079, filed May 10, 1999, the disclosures of both of which applications are incorporated by reference herein.

5

STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER
FEDERALLY SPONSORED RESEARCH AND DEVELOPMENT

Not applicable.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to paper and board machine air impingement methods and apparatus for compensating for the curling tendency of a paper or board web.

[0003] As known in the prior art, multi-cylinder dryer units of a paper machine employ twin-wire draw and/or single-wire draw. In twin-wire draw, the drying cylinder groups comprise two wires which press the web one from above and the other from below against heated cylinder surfaces. Between the drying cylinder rows, generally horizontal rows, there are free and unsupported draws, in which connection the web is susceptible to fluttering, which may cause web breaks, especially when the web is still moist and therefore weak. For this reason, single wire draw has recently been adopted and applied in the dryer unit in practice without an exception, each drying cylinder group of the single wire draw including only one drying wire, on support of which the web runs through the entire group such that, on the drying cylinders, the drying wire presses the web against heated cylinder surfaces, and on the reversing cylinders or rolls between the drying cylinders, the web runs on the outer surface of the drying wire. Typically, the dryer unit of a paper machine comprises 20-30 drying cylinders and reversing cylinders, in which connection a multi-cylinder dryer has 5-8 wire groups and the groups located at the upstream end of the dryer unit are normally shorter than the groups at the downstream end thereof.

[0004] In so-called normal single-wire draw groups of the prior art, the heated drying cylinders are located in an upper row and the reversing cylinders are located in lower rows, which rows are commonly horizontal and parallel to one another. The applicant's *FI patent 54627* (corresponding *US patent 4,202,113*) proposes placing successively above-mentioned normal single-wire groups and so-called inverted single-wire groups, in which heated drying cylinders are located in a lower row and reversing suction cylinders or rolls are located in an upper row with the main purpose of drying the web symmetrically on both sides thereof. Beloit Corp. have also put forward some proposals for dryer units comprising normal and inverted cylinder groups, in respect of which reference is made to international application publications *WO 88/06204* and *WO 88/06205* and to *US patent 4,934,067*, which proposes inverted groups for a dryer unit for control of curl. According to *US patent 5,269,074* (Beloit Corp.), a long dryer unit applying single-wire draw is followed by a short dryer unit applying twin-wire draw with the purpose of controlling curl of the web.

[0005] The use of moist steam for straightening curl has already been known in the art since the 1970's and the 1980's, as appears in *US patent 3,948,721* (Vinheim Karl) or in *US patent 5,557,860* (Voith) and in public *FI patent application 821431*, which teaches passing the web through a steam treatment station in order to straighten curl. Recently, dryer units provided with single-wire draw have become common in which the upper or lower cylinders are steam-heated drying cylinders, the web coming into direct contact with said cylinders while being pressed by the drying wire, and in which the lower or upper cylinders are cylinders provided with internal suction, for example, Metso Paper, Inc.'s so-called **VAC-ROLL™** cylinders in which a vacuum effect is directed through the perforated shell of the cylinders from the interior space of the reversing cylinder to the grooves extending around the shell of the cylinder. Said vacuum effect serves to maintain the web in contact with the drying wire when the web comes to the side of the outside curve on the reversing cylinders. At the same time, the transverse shrinkage of the web is sought to be prevented while drying progresses.

[0006] In paper and board machines, the reeling of the web is usually sought to be carried out when the web is as cold as possible, and in order to achieve this aim, it is prior known that a cooling cylinder is used at the end of the dryer unit. In accordance with the commonly known state of the art, the cooling of the web has the following effects:

- the relaxation time of the web can be shortened, which leads to smaller differences of stress in the web before the next process stage (e.g. calendering or reeling) as compared with a situation that the web is passed forwards at a higher temperature,
- the temperature differences themselves can be reduced by lowering temperature level, which leads to smaller differences in the elastic-plastic behaviour of the web in the next process stage or before it.

[0007] The most substantial problem associated with single-wire draw is that drying heating is directed, i.e. by convection from the surface of a heated drying cylinder, more intensely only at one surface of the web from one direction. As a result of this one-direction heating, there arises a strong tendency to curl in the web. This problem is also previously known and in order to deal with it, several different solutions have been proposed in the course of years. However, it is common to all these solutions that there remain in the web more or less internal stresses which will release in an unpredictable manner at a later stage and may cause problems as soon as in connection with finishing, such as coating and reeling, or later at the stage at which the paper product is utilized.

[0008] With respect to this complex of problems and the prior art associated with the background of the invention, reference is further made to the publications

[0009] **FI 902616** describes a steam box disposed in a dryer unit for relaxation of drying stresses and thus for compensating for curl.

[0010] **FI 931263** describes air impingement against a large cylinder which has a diameter > 2 m and which is placed inside a drying wire loop. Said publication proposes the division of air impingement into sections, in which connection each section uses hot air or superheated steam having a temperature, moisture and/or pressure which is different in each section in order to prevent transverse shrinkage of the web, to control drying of the web and to achieve a desired moisture profile for the web.

[0011] **FI 950434** proposes passing a web, which has a tendency to curl because of the nonsymmetrical forward-drying of the bottom and top surfaces of the web, to finishing in which the tendencies to curl are compensated for by moistening and/or plastically working the web.

[0012] **FI 951748** describes a dryer unit which applies single-wire draw for control of curl and in which the last group is inverted to allow drying on both sides.

[0013] **FI 963734** proposes an arrangement for drying a coated paper web in a drying group of an after-dryer unit applying single-wire draw, the web being treated in said arrangement after that by means of a steam box in order to compensate for the tendency to curl.

[0014] **FI 964830** proposes an arrangement for compensating for the curling tendency of a paper web by means of an air impingement device which is placed above a drying cylinder and by which hot moist air is blown against the web.

[0015] **FI 971301** discloses an arrangement for controlling the curl of a paper web by means of a dryer unit. According to said arrangement, the necessary operations are carried out in several stages while the temperature of the web is below 85 °C. According to the publication, the curl control treatment is accomplished by means of a steam box or a moistening device.

[0016] **FI 971713** proposes arranging a large-diameter air impingement drying cylinder in connection with a dryer unit which applies single-wire draw and has drying cylinders placed below and reversing cylinders placed above, which air impingement drying cylinder is placed inside a drying wire loop and on top or in the vicinity of which cylinder, at both sides, heated smaller-diameter cylinders are placed, whereby, when the web is supported by the drying wire over the entire length of the dryer unit, uneven transverse shrinkage of the web can be prevented and avoided.

[0017] **FI 972080** proposes disposing a steam box and/or a moistening device and/or an infrared dryer after a calender or, if calendering is not employed, in connection with a machine reel or in connection with the finishing process after it in order to compensate for curl of a web.

[0018] Despite numerous approaches of the prior art, it has not been possible to eliminate the curl of the web in paper or board machines and, recently, with increasing running speeds, the curling tendency has been also increased by the more and more common demand for downwardly open dryer units applying single-wire draw to be disposed in paper or board machines in order that the paper or board machine might be placed in a smaller, i.e. lower hall space and that, at the same time, the serviceability of the dryer unit might be improved and the contamination problems kept small. Indeed, a substantial problem with the manufacture of paper and board is still that the control of the profileability of the web is slow, and different elongation streaks, waves or curls arise because of drying stresses, and that paper or board subjected to unequal-sided drying, in particular thin paper grades, such as different directory papers, exhibits very intense wave formation and curl when they come into contact with the moisture of air after the manufacturing process.

SUMMARY OF THE INVENTION

[0019] The primary object of the present invention is to improve compensation for

the curling tendency of a paper or board web and attempt to minimize drying stresses arising in the web and to bring the curling tendency of the web to the range of reversible, or structural curl behaviour, in which connection the web is as free as possible from stresses and cooled for being wound as cold as possible. One further 5 object of the invention is also to make control of the profileability of the web quicker and to increase drying capacity in connection with single-wire draws.

[0020] Thus, the invention is based on a new and inventive basic idea that, in order to minimize the drying stresses of a web, in at least one zone in which the web is treated with air and which extends substantially across the entire width of the web, 10 air impingement directed at the web includes, one following after the other, at least one hot air blowing and at least one cold air blowing in which the cold air used is hall air from the machinery hall surrounding the paper or board machine, cooled hall air and/or moistened hall air. The moisture of such hall air condenses when the air comes into an environment which is warmer than the air, with the result that the web 15 in cold air impingement is not only cooled but also moistened by the action of the blowing air because condensed moisture is condensed and/or absorbed into the web, in which connection the curl behaviour of the web changes with moisture to the range of structural, i.e. reversible curl behaviour, which is conducive to substantially compensating for the curling tendency of paper or board.

[0021] In accordance with the invention, it is advantageous that an air 20 impingement arrangement is arranged in a hood which is located above a drying cylinder, a suction roll or an air-impingement roll, which is advantageously the last drying cylinder, suction roll or air-impingement roll of a dryer unit, and which hood is divided with a partition wall into two sections, in which connection the web is 25 subjected in the machine direction first to a blowing with hot air and after that to a blowing with cold air. In that connection, the air treatment zone of the web comprises a first and a second area which are defined by the bipartite hood at said hood and which extend across the width of the web. In that connection, depending on the drying wire loop arrangement, air impingement can be applied either directly

to the free surface of the web or to the free surface of the drying wire located on the web. As an alternative to a bipartite hood, the air impingement arrangement can comprise in accordance with the invention

- Two successive hoods placed on top of two successive drying cylinders, suction rolls and/or air impingement rolls, in which connection the former hood in the machine direction is advantageously located in connection with the second last drying cylinder, suction roll or air impingement roll and blows hot air against the web and the latter hood in the machine direction is advantageously located in connection with the last drying cylinder, suction roll or air impingement roll and blows cold air against the web. In that connection, the zone for air treatment of the web is bipartite and comprises separately a first area extending across the width of the web and located at the hood blowing hot air and a second area extending across the width of the web and located at the hood blowing cold air;
- A hood arranged in connection with a drying cylinder, a suction roll or an air impingement roll, which is advantageously the last drying cylinder, suction roll or air impingement roll of a dryer unit, which hood blows hot air against the web, and a blow box or an airborne drying unit extending across the web and blowing cold air against the web. In that connection, the zone for air treatment of the web is bipartite and comprises separately a first area extending across the width of the web and located at the hood blowing hot air and a second area extending across the width of the web and located at the blow box or the airborne drying unit blowing cold air.

[0022] In accordance with the embodiments of the invention regarded as preferable, it is advantageous that the temperature of the cold air blowing is $\leq 50^{\circ}\text{C}$. For the purpose of cooling the web further before its further treatment, a cooling cylinder can be arranged to cool the web after the air treatment zone.

[0023] With respect to the benefits of the invention, it may be mentioned that

- balanced drying can be achieved which minimizes the drying stresses arising in paper,

- cooling of the web before calendering equalizes the temperature differences and temperature profiles appearing in it,
- cooling has been found to generally have a favourable effect on the relaxation of the web,

5 - when drying takes place by air impingement, crystallization of lignin caused by single-wire draw cylinders can be avoided and final drying can be carried out at low temperatures,

- the drying capacity of single-wire draw increases substantially, even by 10-15 %,
- control of drying and cooling is quick and therefore the web can be profiled quickly,

10 - when cooling cold air blowing is coupled with hot air blowing, energy can be saved,

- air impingement according to the invention can be applied both in a forward-dryer section and in an after-dryer section,

15 - because of the downwardly open structure, the air impingement arrangement according to the invention makes it possible in a paper or board machine that removal of broke and cleaning of the unit can be carried out directly from machine level and from below the hood,

- when single-wire draw is provided simultaneously with the air impingement

20 arrangement according to the invention, blowers and other auxiliary devices can be placed on the lower level which becomes free or, especially in connection with new machines, the basement space can be left unbuilt altogether in the area of cylinder drying,

- when compared with the cooling of the web accomplished by means of cooling cylinders and on the water-jet principle, the air impingement arrangement according to the invention is
 - clean because no drip water problem is encountered in the invention,
 - advantageous because no displacements of cylinders and a reel are needed, and it also

25 - requires little space, is economical in terms of energy and easy to operate,

- the air impingement according to the invention is suitable for use both in on- and

off-machine dryer sections and calenders, and can also be located in the middle of a dryer section, for example, in on-machine calendering and in intermediate calendering, and

- it can be applied both to coated and to uncoated papers and boards.

5 [0024] With respect to other special features of the invention and to the advantages attainable by them, reference is made to the dependent claims of the accompanying set of claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The invention will be described below with reference to the accompanying drawing in which

10 [0026] FIG. 1 shows generally a paper or board machine which is provided with an air impingement arrangement in accordance with a first advantageous embodiment of the invention,

[0027] FIG. 2 shows the air impingement arrangement in accordance with the first advantageous embodiment of the invention in more detail,

15 [0028] FIG. 3 shows an alternative air impingement arrangement of the first advantageous embodiment of the invention,

[0029] FIG. 4 shows an air impingement arrangement in accordance with a second embodiment of the invention regarded as advantageous,

20 [0030] FIG. 5 shows an alternative air impingement arrangement of the second advantageous embodiment of the invention,

[0031] FIG. 6 shows an air impingement arrangement in accordance with a third embodiment of the invention regarded as advantageous,

[0032] FIG. 7 shows an alternative air impingement arrangement of the third advantageous embodiment of the invention, and

25 [0033] FIG. 8 illustrates the change of curling tendency as a function of moisture content in connection with air impingement in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0034] Fig.1 shows an LWC paper machine which includes:

- a unit 1 for forming a paper or board web 10,
- a press unit 2,
- 5 - a dryer unit 3 which applies single-wire draw,
- a calendering unit 4,
- a first after-dryer unit 5, i.e. located after calendering, which applies twin-wire draw,

and the paper machine shown in Fig. 1 additionally includes as finishing equipment:

- 10 - a coating unit 6 which can be bypassed in the run illustrated in the figure,
- a second after-dryer unit 7, i.e. located after the coating unit 6, which unit applies twin-wire draw, and
- a reeling unit 8.

[0035] As seen from Fig. 1, the dryer unit 3 and both after-dryer units 5 and 7 are provided with an air impingement arrangement 20 disposed in connection with and on top of the last drying cylinder of each of said units in accordance with the invention. An impingement blowing is directed against the web 10 by means of the air impingement arrangement in order to compensate for any curl of the web. The air impingement arrangement 20 extends substantially across the entire width of the web 10 running in the vicinity of, i.e. by and under said arrangement, forming with the web 10 a zone for contact-free treatment of the web with air, in which zone the cold air used for treatment of the web is most advantageously:

- 20 - hall air
- cooled hall air or
- 25 moistened hall air

from the machinery hall surrounding the paper or board machine.

[0036] In accordance with the invention, the impingement applied to the web 10 from the impingement arrangement 20 is thus constituted by a hot blowing and a cold blowing with air, said blowings following one after the other. In that

connection, with the moisture which condenses and/or is absorbed into the web in cold air blowing, the curl behaviour of the web changes to the range of structural, i.e. reversible curl behaviour. In order to assure that moisture is condensed and/or absorbed into the web, it is advantageous that the temperature of the cold air

5 blowing is substantially lower than the temperature of the hot air blowing and/or the temperature of the web 10 running under the air treatment zone. Most commonly, the temperature of the hall air used in cold air blowing is below 30 °C, but the air may be heated in blowers by 15-20 °C. Despite this heating, the cold air which is blown is substantially colder than the temperature of 90-120 °C of the web and/or

10 the surroundings around it at the downstream end of the dryer unit. Advantageously, the temperature of cold air blowing is below 50 °C. When hot and cold air meet each other, the moisture present in the air condenses, being then enabled to pass into the web with the flow of air and to be absorbed into it and/or to condense in it.

[0037] Fig. 1 illustrates two advantageous ways to arrange air impingement in accordance with the invention in a drying zone. Thus, as shown in Fig. 1, air impingement can be directed so as to act either on the top surface of a drying wire 9 located on the web 10 placed against a drying cylinder, in which connection the air impingement arrangement 20 is disposed inside a drying wire loop. This kind of embodiment is illustrated in connection with the dryer unit 3 and the second after-dryer unit 7. Alternatively, air impingement can also be arranged to act directly on the free surface of the web 10 which is free on a drying cylinder, in which connection the air impingement arrangement 20 is located outside a drying wire loop, and the drying wire loop is separated from the web before the air impingement arrangement. This kind of embodiment is illustrated in connection with the first after-dryer unit 5.

[0038] In accordance with the embodiments of the invention considered to be advantageous, the air impingement arrangement 20; 20a, 20b, by means of which the web 10 is first subjected to a hot blowing and then to a cold blowing with air, comprises:

- one hood 20 placed on top of a drying cylinder 23, a suction roll or an air impingement roll, the hood being divided by an internal partition wall 27 into a hot air blowing part 21 and a cold air blowing part 22 (cf. FIG. 2 and FIG. 3),
- two separate hoods 20a and 20b placed on top of successive drying cylinders 23, suction rolls 28 and/or air impingement rolls, the first of the hoods being a hot air blowing part 21 and the second being a cold air blowing part 22 (cf. FIG. 4 and FIG. 5), or
- one hood 20a, placed on top of a drying cylinder 23, a suction roll 28 or an air impingement roll, the hood functioning as a hot air blowing part 21, and a blow box or an airborne drying unit 20b disposed after it and acting on the web, the blow box or the airborne drying unit functioning as a cold air blowing part 22 (cf. FIG. 6 and FIG. 7).

[0039] In the first embodiment of the air impingement arrangement according to the invention shown in Fig. 2, the air impingement arrangement 20 is located inside a drying wire loop and extends across the entire width of the web 10 running under the drying wire 9 in the vicinity thereof, and forms with it a contact-free zone for treatment of the web with air, in which a hot air blowing and a cold air blowing are used for treating the web by impingement, in which the cold air used is advantageously

- hall air,
- cooled hall air, or
- moistened hall air

from the machinery hall surrounding the paper or board machine.

[0040] In accordance with the invention, the hot air blowing and the cold air blowing in the air impingement directed at the web 10 in the air treatment zone follow one after the other, in which connection the cold air blowing makes it possible to:

- cool the web 10, whereby the temperature differences in the web are equalized,
- relax stresses arising in drying, and

- moisten the web 10 by condensing and/or absorbing moisture into it, thus bringing the web 10 to the range of its structural, or reversible, curl behaviour (cf. FIG. 8).

[0041] In the first advantageous embodiment of the air impingement arrangement 5 according to the invention as shown in Fig. 2, the air impingement arrangement includes one hood 20, advantageously disposed in connection with the last drying cylinder 23 of the dryer unit 3, 5, 7 on top of the drying cylinder 23.

[0042] In order to produce a hot air blowing and a cold air blowing, the hood 20 is divided by the partition wall 27 into two sections, of which the first section in the 10 machine direction is the hot air blowing part 21 and the second section is the cold air blowing part 22. In that connection, in the machine direction, the web 10 is first subjected to a blowing with hot air from the hood 20 and after that to a blowing with cold air. In this kind of air impingement arrangement implemented with one hood, the zone for treatment of the web with air is bipartite and comprises a first and a 15 second area defined by the bipartite hood 20 at it and extending across the width of the web 10.

[0043] Fig. 2 illustrates with a broken line one advantageous further application in order to enhance the cooling of the web. In this further application, after the cold blowing part 22 of the air impingement arrangement 20, the web 10 is passed on 20 support of an additional cooling wire 26 against the circumferential surface of an additional cooling cylinder 25. In that connection, it is thus possible to further cool the web 10 in order that it may be calendered as cold as possible. It must be emphasized that this additional feature is not most essential from the point of view 25 of the present invention, but it is described here as a possibility enhancing the cooling effect produced by the cold blowing according to the invention.

[0044] In accordance with one embodiment of the invention considered advantageous, the drying cylinder 23, the suction roll 28 or the air impingement roll

can also be a cooling cylinder known in itself in the state of the art, whereby a cooling effect can be directed at the web 10 from both sides thereof.

[0045] The alternative embodiment of the first advantageous embodiment of the invention shown in Fig. 3 differs from the first advantageous embodiment of the invention shown in Fig. 2 in that

- in the place of the drying cylinder 23, there is a suction roll 28 or an air impingement roll, the roll 28 may be either a suction roll marketed by the applicant under the trademark VAC-roll™, in which roll vacuum is effective on the entire inner surface of the roll (cf. FIG. 3 and FIG 5), or a conventional suction roll provided with a suction zone (cf. FIG. 7), and
- at the air impingement arrangement, as a drying wire there is a drying wire 9' located underneath the web 10.

In that connection, the drying wire 9 meandering with the web 10 in the dryer unit 3, 5, 7 has been arranged to separate from the web 10 before the air impingement arrangement, and in the air impingement arrangement both hot air blowing and cold air blowing take place from above directly and immediately against the free top surface of the web 10. In this way, cooling, relaxation of stresses and equalization of temperature differences are even more effective than in the embodiment shown in Fig. 2, in which hot air and cold air blowings take place through or by means of the drying wire 9 against the web 10.

[0046] In the second embodiment of the air impingement arrangement according to the invention shown in Fig. 4, the bipartite air impingement arrangement 20a, 20b is located inside a drying wire loop and extends across the entire width of the web 10 running under the drying wire 9 in the vicinity thereof, and forms with it a contact-free zone for treatment of the web with air, in which a hot air blowing and a cold air blowing are used for treating the web by impingement, in which connection the cold air is advantageously

- hall air,
- cooled hall air, or

- moistened hall air

from the machinery hall surrounding the paper or board machine.

In accordance with the invention, the hot air blowing and the cold air blowing in the air impingement directed at the web 10 in the air treatment zone follow separately

5 one after the other, in which connection the cold air blowing makes it possible to:

- cool the web 10, whereby the temperature differences in the web are equalized,
- relax stresses arising in drying, and
- moisten the web 10 by condensing and/or absorbing moisture into it, thus

bringing the web 10 to the range of its structural, or reversible, curl behaviour (cf.

10 FIG. 8).

[0047] In the second advantageous embodiment of the air impingement arrangement 20a, 20b according to the invention shown in Fig. 4, the air impingement arrangement includes two hoods, advantageously disposed in connection with the last two drying cylinders 23 of the dryer unit 3, 5, 7 on top of the 15 drying cylinders 23. In order to produce a hot air blowing and a cold air blowing, the first hood 20a in the machine direction constitutes a hot blowing part 21 and the second hood 20b constitutes a cold blowing part 22 of the air impingement arrangement. In other words, in that connection, in the machine direction, the web 10 is subjected to a blowing with hot air from the first hood 20a and after that to a 20 blowing with cold air from the second hood 20b. In this kind of air impingement arrangement accomplished by means of two separate hoods 20a, 20b, the web treatment zone is bipartite and comprises separate first and second areas defined by the hoods 20a and 20b at said hoods and extending across the width of the web 10.

[0048] In accordance with one embodiment of the invention regarded as

25 advantageous, the drying cylinder 23, the suction roll 28 or the air impingement roll may also be a cooling cylinder known in itself in the state of the art, in which connection a cooling effect can be applied to the web 10 from both sides thereof.

[0049] The alternative embodiment of the second advantageous embodiment of the

invention shown in Fig. 5 differs from the second alternative advantageous embodiment of the invention shown in Fig. 4 in that

- in the place of the drying cylinders 23, there are suction rolls 28 and/or air impingement rolls, and
- at the air impingement arrangement, as a drying wire there is a drying wire 9' located underneath the web 10.

5 In that connection, the drying wire 9 meandering with the web 10 in the dryer unit 3, 5, 7 has been arranged to separate from the web 10 before the air impingement arrangement, and in the air impingement arrangement both hot air blowing and cold 10 air blowing take place from above directly and immediately against the free top surface of the web 10. In this way, cooling, relaxation of stresses and equalization of temperature differences are even more effective than in the embodiment shown in Fig. 2, in which hot air and cold air blowings take place through or by means of the 15 drying wire 9 against the web 10.

15 [0050] In the third embodiment of the air impingement arrangement according to the invention shown in Fig. 6, the bipartite air impingement arrangement 20a, 20b is located inside a drying wire loop and extends across the entire width of the web 10 running under the drying wire 9 in the vicinity thereof, and forms with it a contact-free zone for treatment of the web with air, in which a hot air blowing and a cold air blowing are used for treating the web by impingement, in which connection the cold 20 air is advantageously

- hall air,
- cooled hall air, or
- moistened hall air

25 from the machinery hall surrounding the paper or board machine.

In accordance with the invention, the hot air blowing and the cold air blowing in the air impingement directed at the web 10 in the air treatment zone follow separately one after the other, in which connection the cold air blowing makes it possible to:

- cool the web 10, whereby the temperature differences in the web are equalized,
- relax stresses arising in drying, and

- moisten the web 10 by condensing and/or absorbing moisture into it, thus bringing the web 10 to the range of its structural, or reversible, curl behaviour (cf. FIG. 8).

[0051] The air impingement arrangement 20a, 20b according to the third
5 advantageous embodiment of the invention shown in Fig. 6 includes a hood 20b,
advantageously placed in connection with the last two drying cylinders 23 of the
dryer unit 3, 5, 7 on top of the dryer cylinders 23, and a blow box or an airborne
drying unit 20b extending across the web 10 and blowing cold air against the web.

[0052] In order to provide a hot air blowing and a cold air blowing in the machine
10 direction, the hood 20a constitutes the hot air blowing part 21 of the air impingement
arrangement and the blow box or the airborne drying unit 20b constitutes the cold air
blowing part 22 of the air impingement arrangement. In other words, in that
connection, in the machine direction, the web 10 is subjected to a blowing with hot
air from the hood 20a and after that to a blowing with cold air from the second blow
15 box or the airborne drying unit 20b. In this kind of air impingement arrangement
accomplished by means of a hood 20a and a blow box or an airborne drying unit 20b
which are separate from each other, the web treatment zone is bipartite and
comprises separate first and second areas which extend across the width of the web
10 and are defined by the hood 20a and the blow box or the airborne drying unit 20b
20 at the hood and at the blow box or the airborne drying unit.

[0053] In accordance with one embodiment of the invention regarded as
advantageous, the drying cylinder 23, the suction roll 28 or the air impingement roll
may also be a cooling cylinder known in itself in the state of the art, in which
connection a cooling effect can be applied to the web 10 from both sides thereof.

25 [0054] The alternative embodiment of the third advantageous embodiment of the
invention shown in Fig. 7 differs from the third advantageous embodiment of the
invention shown in Fig. 6 in that

- in the place of the drying cylinders 23, there is a suction roll 28 or an air impingement roll, and
- at the air impingement arrangement, as a drying wire there is a drying wire 9' located underneath the web 10.

5 [0055] In that connection, the drying wire 9 meandering with the web 10 in the dryer unit 3, 5, 7 has been arranged to separate from the web 10 before the air impingement arrangement, and in the air impingement arrangement both hot air blowing and cold air blowing take place from above directly and immediately against the free top surface of the web 10. In this way, cooling, relaxation of stresses
10 and equalization of temperature differences are even more effective than in the embodiment shown in Fig. 2, in which hot air and cold air blowings take place through or by means of the drying wire 9 against the web 10.

15 [0056] Fig. 8 illustrates the effect of the drying operations applied to paper on the curl of paper. The behaviour of paper has been changed by means of drying stresses with respect to its structural curl. In the figure, the structural curl of paper is shown by the upper line of dots and dashes and its range is reached:

- by drying the paper from an initial state in which the curl = 1 CD curl/m and the moisture content = 7.2 % to a predried state in which the curl = 3.3 CD curl/m and the moisture content = 3.5 %, and then
- allowing the paper to be moistened from the predried state to the initial state of structural curl behaviour in which the curl = 2.5 CD curl/m and the moisture content = 7.2 %.
- After that, in spite of drying or rewetting of the paper, the curl of the paper is predictable and remains in the range of reversible structural curl behaviour.

25 This relaxation of drying stresses according to the invention make it possible to assure that the stresses are in balance such that at final moisture the paper is already at the curve of structural curl and moisture shown in Fig. 8, and unpredictable curl of the paper does not cause any problems in the finishing or subsequent utilization of the paper.

[0057] Above, the invention has been described only by means of some of its embodiments regarded as advantageous and by means of some of their alternative embodiments. This is naturally not intended to limit the invention so as to relate only to this kind of single embodiments. Thus, as is clear to a person skilled in the art, 5 many variations and alternative solutions are feasible within the inventive idea and within the scope of protection defined in the accompanying claims.

(Note: Claims are found in the preliminary amendment filed simultaneously herewith.)

ABSTRACT OF THE DISCLOSURE

An air impingement arrangement and method for compensating for the curling tendency of a paper or board web which is being treated. Air impingement is disposed in connection with a paper or board process or with its finishing process and extends across the width of the web (10) running in the vicinity thereof, forming a contact-free web treatment zone, in which process the web is dried in at least one dryer unit (3, 5, 7) that applies single-wire draw. In accordance with the invention, air impingement directed at the web (10) is produced by the air impingement arrangement (20) in the web treatment zone, said air impingement including, one following after the other, at least one hot blowing with air and at least one cold blowing with air. The invention also relates to a paper or board machine provided with this kind of air impingement arrangement.

METHOD AND ARRANGEMENT OF IMPINGEMENT FOR BLOWING
COMPENSATION OF A TENDENCY OF CURLING OF A PAPER BOARD WEB
TO BE TREATED AS WELL AS A PAPER OR BOARD MACHINE

5

10 The present invention relates to paper or board machines. More specifically, the present invention relates to an air impingement arrangement according to the preamble of claim 1 and to an air impingement method according to the preamble of claim 16 as well as to a paper or board machine according to the preamble of claim 25 for compensating for the curling tendency of a paper or board web to be treated.

15 As known in the prior art, multi-cylinder dryer units of a paper machine employ twin-wire draw and/or single-wire draw. In twin-wire draw, the drying cylinder groups comprise two wires which press the web one from above and the other from below against heated cylinder surfaces. Between the drying cylinder rows, generally horizontal rows, there are free and unsupported draws, in which connection the web is susceptible to fluttering, which may cause web breaks, especially when the web is still moist and therefore weak.

20 For this reason, single wire draw has recently been adopted and applied in the dryer unit in practice without an exception, each drying cylinder group of the single wire draw including only one drying wire, on support of which the web runs through the entire group such that, on the drying cylinders, the drying wire presses the web against heated cylinder surfaces, and on the reversing cylinders or rolls between the drying cylinders, the web runs 25 on the outer surface of the drying wire. Typically, the dryer unit of a paper machine comprises 20-30 drying cylinders and reversing cylinders, in which connection a multi-cylinder dryer has 5-8 wire groups and the groups located at the upstream end of the dryer unit are normally shorter than the groups at the downstream end thereof.

30 In so-called normal single-wire draw groups of the prior art, the heated drying cylinders are located in an upper row and the reversing cylinders are located in lower rows, which rows are commonly horizontal and parallel to one another. The applicant's *FI patent*

54627 (corresponding *US patent 4,202,113*) proposes placing successively above-mentioned normal single-wire groups and so-called inverted single-wire groups, in which heated drying cylinders are located in a lower row and reversing suction cylinders or rolls are located in an upper row with the main purpose of drying the web symmetrically on 5 both sides thereof. Beloit Corp. have also put forward some proposals for dryer units comprising normal and inverted cylinder groups, in respect of which reference is made to international application publications *WO 88/06204* and *WO 88/06205* and to *US patent 4,934,067*, which proposes inverted groups for a dryer unit for control of curl. According to *US patent 5,269,074* (Beloit Corp.), a long dryer unit applying single-wire draw is 10 followed by a short dryer unit applying twin-wire draw with the purpose of controlling curl of the web.

The use of moist steam for straightening curl has already been known in the art since the 15 1970's and the 1980's, as appears in *US patent 3,948,721* (Vinheim Karl) or in *US patent 5,557,860* (Voith) and in public *FI patent application 821431*, which teaches passing the web through a steam treatment station in order to straighten curl. Recently, dryer units provided with single-wire draw have become common in which the upper or lower cylinders are steam-heated drying cylinders, the web coming into direct contact with said cylinders while being pressed by the drying wire, and in which the lower or upper 20 cylinders are cylinders provided with internal suction, for example, the applicant's so-called **VAC-ROLL™** cylinders in which a vacuum effect is directed through the perforated shell of the cylinders from the interior space of the reversing cylinder to the grooves extending around the shell of the cylinder. Said vacuum effect serves to maintain the web 25 in contact with the drying wire when the web comes to the side of the outside curve on the reversing cylinders. At the same time, the transverse shrinkage of the web is sought to be prevented while drying progresses.

In paper and board machines, the reeling of the web is usually sought to be carried out when the web is as cold as possible, and in order to achieve this aim, it is prior known that 30 a cooling cylinder is used at the end of the dryer unit. In accordance with the commonly known state of the art, the cooling of the web has the following effects:

- the relaxation time of the web can be shortened, which leads to smaller differences of stress in the web before the next process stage (e.g. calendering or reeling) as compared with a situation that the web is passed forwards at a higher temperature,
- the temperature differences themselves can be reduced by lowering temperature level,

5 which leads to smaller differences in the elastic-plastic behaviour of the web in the next process stage or before it.

10 The most substantial problem associated with single-wire draw is that drying heating is directed, i.e. by convection from the surface of a heated drying cylinder, more intensely only at one surface of the web from one direction. As a result of this one-direction heating, there arises a strong tendency to curl in the web. This problem is also previously known and in order to deal with it, several different solutions have been proposed in the course of years. However, it is common to all these solutions that there remain in the web more or less internal stresses which will release in an unpredictable manner at a later stage and 15 may cause problems as soon as in connection with finishing, such as coating and reeling, or later at the stage at which the paper product is utilized.

20 With respect to this complex of problems and the prior art associated with the background of the invention, reference is further made to the publications

FI 902616

describes a steam box disposed in a dryer unit for relaxation of drying stresses and thus for compensating for curl.

FI 931263

25 describes air impingement against a large cylinder which has a diameter > 2 m and which is placed inside a drying wire loop. Said publication proposes the division of air impingement into sections, in which connection each section uses hot air or superheated steam having a temperature, moisture and/or pressure which is different in each section in order to prevent transverse shrinkage of the web, to control drying of the web and to achieve a desired 30 moisture profile for the web.

FI 950434

proposes passing a web, which has a tendency to curl because of the nonsymmetrical forward-drying of the bottom and top surfaces of the web, to finishing in which the tendencies to curl are compensated for by moistening and/or plastically working the web.

5

FI 951748

describes a dryer unit which applies single-wire draw for control of curl and in which the last group is inverted to allow drying on both sides.

FI 963734

10 proposes an arrangement for drying a coated paper web in a drying group of an after-dryer unit applying single-wire draw, the web being treated in said arrangement after that by means of a steam box in order to compensate for the tendency to curl.

15 proposes an arrangement for compensating for the curling tendency of a paper web by means of an air impingement device which is placed above a drying cylinder and by which hot moist air is blown against the web.

FI 971301

20 discloses an arrangement for controlling the curl of a paper web by means of a dryer unit. According to said arrangement, the necessary operations are carried out in several stages while the temperature of the web is below 85 °C. According to the publication, the curl control treatment is accomplished by means of a steam box or a moistening device.

FI 971713

25 proposes arranging a large-diameter air impingement drying cylinder in connection with a dryer unit which applies single-wire draw and has drying cylinders placed below and reversing cylinders placed above, which air impingement drying cylinder is placed inside a drying wire loop and on top or in the vicinity of which cylinder, at both sides, heated smaller-diameter cylinders are placed, whereby, when the web is supported by the drying wire over

20001760 00000000

the entire length of the dryer unit, uneven transverse shrinkage of the web can be prevented and avoided.

FI 972080

5 proposes disposing a steam box and/or a moistening device and/or an infrared dryer after a calender or, if calendering is not employed, in connection with a machine reel or in connection with the finishing process after it in order to compensate for curl of a web.

10 Despite numerous approaches of the prior art, it has not been possible to eliminate the curl of the web in paper or board machines and, recently, with increasing running speeds, the curling tendency has been also increased by the more and more common demand for downwardly open dryer units applying single-wire draw to be disposed in paper or board machines in order that the paper or board machine might be placed in a smaller, i.e. lower hall space and that, at the same time, the serviceability of the dryer unit might be improved and the contamination problems kept small. Indeed, a substantial problem with the manufacture of paper and board is still that the control of the profileability of the web is slow, and different elongation streaks, waves or curls arise because of drying stresses, and that paper or board subjected to unequal-sided drying, in particular thin paper grades, such as different directory papers, exhibits very intense wave formation and curl when they come into contact with the moisture of air after the manufacturing process.

15

20 The primary object of the present invention is to improve compensation for the curling tendency of a paper or board web and attempt to minimize drying stresses arising in the web and to bring the curling tendency of the web to the range of reversible, or structural curl behaviour, in which connection the web is as free as possible from stresses and cooled for being wound as cold as possible. One further object of the invention is also to make control of the profileability of the web quicker and to increase drying capacity in connection with single-wire draws.

25

30 This primary object of the present invention is achieved by means of an air impingement arrangement of the kind mentioned at the beginning, the special features characteristic of

said arrangement being set forth in the independent claim 1 of the accompanying set of claims, by means of an air impingement method, the special features characteristic of said method being set forth in the independent claim 16 of the accompanying set of claims, and by means of a paper or board machine, the special features characteristic of said machine being set forth in the independent claim 25 of the accompanying set of claims.

Thus, the invention is based on a new and inventive basic idea that, in order to minimize the drying stresses of a web, in at least one zone in which the web is treated with air and which extends substantially across the entire width of the web, air impingement directed

at the web includes, one following after the other, at least one hot air blowing and at least one cold air blowing in which the cold air used is hall air from the machinery hall surrounding the paper or board machine, cooled hall air and/or moistened hall air. The moisture of such hall air condenses when the air comes into an environment which is warmer than the air, with the result that the web in cold air impingement is not only cooled but also moistened by the action of the blowing air because condensed moisture is condensed and/or absorbed into the web, in which connection the curl behaviour of the web changes with moisture to the range of structural, i.e. reversible curl behaviour, which is conducive to substantially compensating for the curling tendency of paper or board.

In accordance with the invention, it is advantageous that an air impingement arrangement is arranged in a hood which is located above a drying cylinder, a suction roll or an air-impingement roll, which is advantageously the last drying cylinder, suction roll or air-impingement roll of a dryer unit, and which hood is divided with a partition wall into two sections, in which connection the web is subjected in the machine direction first to a blowing with hot air and after that to a blowing with cold air. In that connection, the air treatment zone of the web comprises a first and a second area which are defined by the bipartite hood at said hood and which extend across the width of the web. In that connection, depending on the drying wire loop arrangement, air impingement can be applied either directly to the free surface of the web or to the free surface of the drying wire located on the web. As an alternative to a bipartite hood, the air impingement arrangement can comprise in accordance with the invention

PCT/FI00/00410

- Two successive hoods placed on top of two successive drying cylinders, suction rolls and/or air impingement rolls, in which connection the former hood in the machine direction is advantageously located in connection with the second last drying cylinder, suction roll or air impingement roll and blows hot air against the web and the latter

5 hood in the machine direction is advantageously located in connection with the last drying cylinder, suction roll or air impingement roll and blows cold air against the web. In that connection, the zone for air treatment of the web is bipartite and comprises separately a first area extending across the width of the web and located at the hood blowing hot air and a second area extending across the width of the web and located at the hood blowing cold air;

10 A hood arranged in connection with a drying cylinder, a suction roll or an air impingement roll, which is advantageously the last drying cylinder, suction roll or air impingement roll of a dryer unit, which hood blows hot air against the web, and a blow box or an airborne drying unit extending across the web and blowing cold air against the web. In that connection, the zone for air treatment of the web is bipartite and comprises separately a first area extending across the width of the web and located at the hood blowing hot air and a second area extending across the width of the web and located at the blow box or the airborne drying unit blowing cold air.

15 20 In accordance with the embodiments of the invention regarded as preferable, it is advantageous that the temperature of the cold air blowing is $\leq 50^{\circ}\text{C}$. For the purpose of cooling the web further before its further treatment, a cooling cylinder can be arranged to cool the web after the air treatment zone.

25 With respect to the benefits of the invention, it may be mentioned that

- balanced drying can be achieved which minimizes the drying stresses arising in paper,
- cooling of the web before calendering equalizes the temperature differences and temperature profiles appearing in it,
- cooling has been found to generally have a favourable effect on the relaxation of the

30 web,

- when drying takes place by air impingement, crystallization of lignin caused by single-wire draw cylinders can be avoided and final drying can be carried out at low temperatures,
- the drying capacity of single-wire draw increases substantially, even by 10-15 %,
- 5 - control of drying and cooling is quick and therefore the web can be profiled quickly,
- when cooling cold air blowing is coupled with hot air blowing, energy can be saved,
- air impingement according to the invention can be applied both in a forward-dryer section and in an after-dryer section,
- because of the downwardly open structure, the air impingement arrangement according to the invention makes it possible in a paper or board machine that removal of
- 10 broke and cleaning of the unit can be carried out directly from machine level and from below the hood,
- when single-wire draw is provided simultaneously with the air impingement arrangement according to the invention, blowers and other auxiliary devices can be placed on the lower level which becomes free or, especially in connection with new machines, the basement space can be left unbuilt altogether in the area of cylinder drying,
- 15 - when compared with the cooling of the web accomplished by means of cooling cylinders and on the water-jet principle, the air impingement arrangement according to the invention is
- 20 - clean because no drip water problem is encountered in the invention,
- advantageous because no displacements of cylinders and a reel are needed, and it also
- requires little space, is economical in terms of energy and easy to operate,
- the air impingement according to the invention is suitable for use both in on- and off-
- 25 machine dryer sections and calenders, and can also be located in the middle of a dryer section, for example, in on-machine calendering and in intermediate calendering, and
- it can be applied both to coated and to uncoated papers and boards.

With respect to other special features of the invention and to the advantages attainable by

30 them, reference is made to the dependent claims of the accompanying set of claims.

The invention will be described below with reference to the accompanying drawing in which

FIG. 1 shows generally a paper or board machine which is provided with an air impingement arrangement in accordance with a first advantageous embodiment of the invention,

5 FIG. 2 shows the air impingement arrangement in accordance with the first advantageous embodiment of the invention in more detail,

FIG. 3 shows an alternative air impingement arrangement of the first advantageous embodiment of the invention,

10 FIG. 4 shows an air impingement arrangement in accordance with a second embodiment of the invention regarded as advantageous,

FIG. 5 shows an alternative air impingement arrangement of the second advantageous embodiment of the invention,

FIG. 6 shows an air impingement arrangement in accordance with a third embodiment of the invention regarded as advantageous,

15 FIG. 7 shows an alternative air impingement arrangement of the third advantageous embodiment of the invention, and

FIG. 8 illustrates the change of curling tendency as a function of moisture content in connection with air impingement in accordance with the invention.

20 Fig. 1 shows an LWC paper machine which includes:

- a unit 1 for forming a paper or board web 10,
- a press unit 2,
- a dryer unit 3 which applies single-wire draw,
- a calendering unit 4,

25 - a first after-dryer unit 5, i.e. located after calendering, which applies twin-wire draw, and the paper machine shown in Fig. 1 additionally includes as finishing equipment:

- a coating unit 6 which can be bypassed in the run illustrated in the figure,
- a second after-dryer unit 7, i.e. located after the coating unit 6, which unit applies twin-wire draw, and

30 - a reeling unit 8.

As seen from Fig. 1, the dryer unit 3 and both after-dryer units 5 and 7 are provided with an air impingement arrangement 20 disposed in connection with and on top of the last drying cylinder of each of said units in accordance with the invention. An impingement blowing is directed against the web 10 by means of the air impingement arrangement in order to compensate for any curl of the web. The air impingement arrangement 20 extends substantially across the entire width of the web 10 running in the vicinity of, i.e. by and under said arrangement, forming with the web 10 a zone for contact-free treatment of the web with air, in which zone the cold air used for treatment of the web is most advantageously:

10 - hall air
- cooled hall air or
- moistened hall air

from the machinery hall surrounding the paper or board machine.

15 In accordance with the invention, the impingement applied to the web 10 from the impingement arrangement 20 is thus constituted by a hot blowing and a cold blowing with air, said blowings following one after the other. In that connection, with the moisture which condenses and/or is absorbed into the web in cold air blowing, the curl behaviour of the web changes to the range of structural, i.e. reversible curl behaviour. In order to assure that moisture is condensed and/or absorbed into the web, it is advantageous that the temperature of the cold air blowing is substantially lower than the temperature of the hot air blowing and/or the temperature of the web 10 running under the air treatment zone. Most commonly, the temperature of the hall air used in cold air blowing is below 30 °C, but the air may be heated in blowers by 15-20 °C. Despite this heating, the cold air which is blown is substantially colder than the temperature of 90-120 °C of the web and/or the surroundings around it at the downstream end of the dryer unit. Advantageously, the temperature of cold air blowing is below 50 °C. When hot and cold air meet each other, the moisture present in the air condenses, being then enabled to pass into the web with the flow of air and to be absorbed into it and/or to condense in it.

Fig. 1 illustrates two advantageous ways to arrange air impingement in accordance with the invention in a drying zone. Thus, as shown in Fig. 1, air impingement can be directed so as to act either on the top surface of a drying wire 9 located on the web 10 placed against a drying cylinder, in which connection the air impingement arrangement 20 is disposed inside a drying wire loop. This kind of embodiment is illustrated in connection with the dryer unit 3 and the second after-dryer unit 7. Alternatively, air impingement can also be arranged to act directly on the free surface of the web 10 which is free on a drying cylinder, in which connection the air impingement arrangement 20 is located outside a drying wire loop, and the drying wire loop is separated from the web before the air impingement arrangement. This kind of embodiment is illustrated in connection with the first after-dryer unit 6.

In accordance with the embodiments of the invention considered to be advantageous, the air impingement arrangement 20; 20a, 20b, by means of which the web 10 is first subjected to a hot blowing and then to a cold blowing with air, comprises:

- one hood 20 placed on top of a drying cylinder 23, a suction roll or an air impingement roll, the hood being divided by an internal partition wall 27 into a hot air blowing part 21 and a cold air blowing part 22 (cf. FIG. 2 and FIG. 3),
- two separate hoods 20a and 20b placed on top of successive drying cylinders 23, suction rolls 28 and/or air impingement rolls, the first of the hoods being a hot air blowing part 21 and the second being a cold air blowing part 22 (cf. FIG. 4 and FIG. 5), or
- one hood 20a, placed on top of a drying cylinder 23, a suction roll 28 or an air impingement roll, the hood functioning as a hot air blowing part 21, and a blow box or an airborne drying unit 20b disposed after it and acting on the web, the blow box or the airborne drying unit functioning as a cold air blowing part 22 (cf. FIG. 6 and FIG. 7).

In the first embodiment of the air impingement arrangement according to the invention shown in Fig. 2, the air impingement arrangement 20 is located inside a drying wire loop and extends across the entire width of the web 10 running under the drying wire 9 in the

vicinity thereof, and forms with it a contact-free zone for treatment of the web with air, in which a hot air blowing and a cold air blowing are used for treating the web by impingement, in which the cold air used is advantageously

- hall air,
- 5 - cooled hall air, or
- moistened hall air

from the machinery hall surrounding the paper or board machine.

In accordance with the invention, the hot air blowing and the cold air blowing in the air impingement directed at the web 10 in the air treatment zone follow one after the other, in
10 which connection the cold air blowing makes it possible to:

- cool the web 10, whereby the temperature differences in the web are equalized,
- relax stresses arising in drying, and
- moisten the web 10 by condensing and/or absorbing moisture into it, thus bringing the web 10 to the range of its structural, or reversible, curl behaviour (cf. FIG. 8).

15

In the first advantageous embodiment of the air impingement arrangement according to the invention as shown in Fig. 2, the air impingement arrangement includes one hood 20, advantageously disposed in connection with the last drying cylinder 23 of the dryer unit 3, 5, 7 on top of the drying cylinder 23.

20

In order to produce a hot air blowing and a cold air blowing, the hood 20 is divided by the partition wall 27 into two sections, of which the first section in the machine direction is the hot air blowing part 21 and the second section is the cold air blowing part 22. In that connection, in the machine direction, the web 10 is first subjected to a blowing with hot air from the hood 20 and after that to a blowing with cold air. In this kind of air impingement arrangement implemented with one hood, the zone for treatment of the web with air is bipartite and comprises a first and a second area defined by the bipartite hood 20 at it and extending across the width of the web 10.

25

30

Fig. 2 illustrates with a broken line one advantageous further application in order to enhance the cooling of the web. In this further application, after the cold blowing part 22

of the air impingement arrangement 20, the web 10 is passed on support of an additional cooling wire 26 against the circumferential surface of an additional cooling cylinder 25. In that connection, it is thus possible to further cool the web 10 in order that it may be calendered as cold as possible. It must be emphasized that this additional feature is not most essential from the point of view of the present invention, but it is described here as a possibility enhancing the cooling effect produced by the cold blowing according to the invention.

In accordance with one embodiment of the invention considered advantageous, the drying cylinder 23, the suction roll 28 or the air impingement roll can also be a cooling cylinder known in itself in the state of the art, whereby a cooling effect can be directed at the web 10 from both sides thereof.

The alternative embodiment of the first advantageous embodiment of the invention shown in Fig. 3 differs from the first advantageous embodiment of the invention shown in Fig. 2 in that

- in the place of the drying cylinder 23, there is a suction roll 28 or an air impingement roll, the suction roll 28 may be either a suction roll marketed by the applicant under the trademark VAC-roll™, in which roll vacuum is effective on the entire inner surface of the roll (cf. FIG. 3 and FIG 5), or a conventional suction roll provided with a suction zone (cf. FIG. 7), and
- at the air impingement arrangement, as a drying wire there is a drying wire 9' located underneath the web 10.

In that connection, the drying wire 9 meandering with the web 10 in the dryer unit 3, 5, 7 has been arranged to separate from the web 10 before the air impingement arrangement, and in the air impingement arrangement both hot air blowing and cold air blowing take place from above directly and immediately against the free top surface of the web 10. In this way, cooling, relaxation of stresses and equalization of temperature differences are even more effective than in the embodiment shown in Fig. 2, in which hot air and cold air blowings take place through or by means of the drying wire 9 against the web 10.

In the second embodiment of the air impingement arrangement according to the invention shown in Fig. 4, the bipartite air impingement arrangement 20a, 20b is located inside a drying wire loop and extends across the entire width of the web 10 running under the drying wire 9 in the vicinity thereof, and forms with it a contact-free zone for treatment of 5 the web with air, in which a hot air blowing and a cold air blowing are used for treating the web by impingement, in which connection the cold air is advantageously

- hall air,
- cooled hall air, or
- moistened hall air

10 from the machinery hall surrounding the paper or board machine.

In accordance with the invention, the hot air blowing and the cold air blowing in the air impingement directed at the web 10 in the air treatment zone follow separately one after the other, in which connection the cold air blowing makes it possible to:

- cool the web 10, whereby the temperature differences in the web are equalized,
- relax stresses arising in drying, and
- moisten the web 10 by condensing and/or absorbing moisture into it, thus bringing the web 10 to the range of its structural, or reversible, curl behaviour (cf. FIG. 8).

20 In the second advantageous embodiment of the air impingement arrangement 20a, 20b according to the invention shown in Fig. 4, the air impingement arrangement includes two hoods, advantageously disposed in connection with the last two drying cylinders 23 of the dryer unit 3, 5, 7 on top of the drying cylinders 23. In order to produce a hot air blowing and a cold air blowing, the first hood 20a in the machine direction constitutes a hot blowing part 21 and the second hood 20b constitutes a cold blowing part 22 of the air impingement arrangement. In other words, in that connection, in the machine direction, 25 the web 10 is subjected to a blowing with hot air from the first hood 20a and after that to a blowing with cold air from the second hood 20b. In this kind of air impingement arrangement accomplished by means of two separate hoods 20a, 20b, the web treatment zone is bipartite and comprises separate first and second areas defined by the hoods 20a and 20b at said hoods and extending across the width of the web 10.

In accordance with one embodiment of the invention regarded as advantageous, the drying cylinder 23, the suction roll 28 or the air impingement roll may also be a cooling cylinder known in itself in the state of the art, in which connection a cooling effect can be applied to the web 10 from both sides thereof.

5

The alternative embodiment of the second advantageous embodiment of the invention shown in Fig. 5 differs from the second alternative advantageous embodiment of the invention shown in Fig. 4 in that

- in the place of the drying cylinders 23, there are suction rolls 28 and/or air impingement rolls, and
- at the air impingement arrangement, as a drying wire there is a drying wire 9' located underneath the web 10.

10

In that connection, the drying wire 9 meandering with the web 10 in the dryer unit 3, 5, 7 has been arranged to separate from the web 10 before the air impingement arrangement, and in the air impingement arrangement both hot air blowing and cold air blowing take place from above directly and immediately against the free top surface of the web 10. In this way, cooling, relaxation of stresses and equalization of temperature differences are even more effective than in the embodiment shown in Fig. 2, in which hot air and cold air blowings take place through or by means of the drying wire 9 against the web 10.

15

20

In the third embodiment of the air impingement arrangement according to the invention shown in Fig. 6, the bipartite air impingement arrangement 20a, 20b is located inside a drying wire loop and extends across the entire width of the web 10 running under the drying wire 9 in the vicinity thereof, and forms with it a contact-free zone for treatment of the web with air, in which a hot air blowing and a cold air blowing are used for treating the web by impingement, in which connection the cold air is advantageously

25

- hall air,
- cooled hall air, or
- moistened hall air

30

from the machinery hall surrounding the paper or board machine.

In accordance with the invention, the hot air blowing and the cold air blowing in the air impingement directed at the web 10 in the air treatment zone follow separately one after the other, in which connection the cold air blowing makes it possible to:

- cool the web 10, whereby the temperature differences in the web are equalized,
- relax stresses arising in drying, and
- moisten the web 10 by condensing and/or absorbing moisture into it, thus bringing the web 10 to the range of its structural, or reversible, curl behaviour (cf. FIG. 8).

The air impingement arrangement 20a, 20b according to the third advantageous embodiment of the invention shown in Fig. 6 includes a hood 20b, advantageously placed in connection with the last two drying cylinders 23 of the dryer unit 3, 5, 7 on top of the dryer cylinders 23, and a blow box or an airborne drying unit 20b extending across the web 10 and blowing cold air against the web.

In order to provide a hot air blowing and a cold air blowing in the machine direction, the hood 20a constitutes the hot air blowing part 21 of the air impingement arrangement and the blow box or the airborne drying unit 20b constitutes the cold air blowing part 22 of the air impingement arrangement. In other words, in that connection, in the machine direction, the web 10 is subjected to a blowing with hot air from the hood 20a and after that to a blowing with cold air from the second blow box or the airborne drying unit 20b. In this kind of air impingement arrangement accomplished by means of a hood 20a and a blow box or an airborne drying unit 20b which are separate from each other, the web treatment zone is bipartite and comprises separate first and second areas which extend across the width of the web 10 and are defined by the hood 20a and the blow box or the airborne drying unit 20b at the hood and at the blow box or the airborne drying unit.

In accordance with one embodiment of the invention regarded as advantageous, the drying cylinder 23, the suction roll 28 or the air impingement roll may also be a cooling cylinder known in itself in the state of the art, in which connection a cooling effect can be applied to the web 10 from both sides thereof.

The alternative embodiment of the third advantageous embodiment of the invention shown in Fig. 7 differs from the third advantageous embodiment of the invention shown in Fig. 6 in that

- in the place of the drying cylinders 23, there is a suction roll 28 or an air impingement 5 roll, and
- at the air impingement arrangement, as a drying wire there is a drying wire 9' located underneath the web 10.

In that connection, the drying wire 9 meandering with the web 10 in the dryer unit 3, 5, 7 has been arranged to separate from the web 10 before the air impingement arrangement, 10 and in the air impingement arrangement both hot air blowing and cold air blowing take place from above directly and immediately against the free top surface of the web 10. In this way, cooling, relaxation of stresses and equalization of temperature differences are even more effective than in the embodiment shown in Fig. 2, in which hot air and cold air blowings take place through or by means of the drying wire 9 against the web 10.

15 Fig. 8 illustrates the effect of the drying operations applied to paper on the curl of paper. The behaviour of paper has been changed by means of drying stresses with respect to its structural curl. In the figure, the structural curl of paper is shown by the upper line of dots and dashes and its range is reached:

- by drying the paper from an initial state in which the curl = 1 CD curl/m and the moisture content = 7.2 % to a predried state in which the curl = 3.3 CD curl/m and the moisture content = 3.5 %, and then
- allowing the paper to be moistened from the predried state to the initial state of structural curl behaviour in which the curl = 2.5 CD curl/m and the moisture content = 7.2 %.
- After that, in spite of drying or rewetting of the paper, the curl of the paper is predictable and remains in the range of reversible structural curl behaviour.

20 This relaxation of drying stresses according to the invention make it possible to assure that the stresses are in balance such that at final moisture the paper is already at the curve of structural curl and moisture shown in Fig. 5, and unpredictable curl of the paper does not 25 cause any problems in the finishing or subsequent utilization of the paper.

Above, the invention has been described only by means of some of its embodiments regarded as advantageous and by means of some of their alternative embodiments. This is naturally not intended to limit the invention so as to relate only to this kind of single embodiments. Thus, as is clear to a person skilled in the art, many variations and alternative solutions are feasible within the inventive idea and within the scope of protection defined in the accompanying claims.

Claims

1. An air impingement arrangement for compensating for the curling tendency of a paper or board web which is being treated, which air impingement arrangement (20; 20a, 20b)

5 is disposed in connection with a paper or board process or with a related finishing process and extends substantially across the entire width of the web (10) running in the vicinity thereof and forms a contact-free web treatment zone, in which paper, board and/or finishing process the web is dried in at least one dryer unit (3, 5, 7) which comprises one or preferably several downwardly open single-wire draw groups, and in which paper, board and/or finishing process, optionally, in the dryer unit and/or after it, the web is subjected to an operation or operations which is/are selected from a group which includes reeling, calendering (4), intermediate calendering, coating (6), and additional drying (5, 7), characterized in that the air impingement produced in the web treatment zone by means of the air impingement arrangement (20; 20a, 20b) and directed at the web (10) includes, one following after the other, at least one hot blowing with air and at least one cold blowing with air.

10 2. An air impingement arrangement according to claim 1, characterized in that with the moisture which condenses and/or is absorbed into the web (10) in cold air blowing, the curl behaviour of the web changes to the range of structural, i.e. reversible curl behaviour.

15 3. An air impingement arrangement according to claim 1 and/or 2, characterized in that the air impingement in the air treatment zone of the web is applied to the free surface of the web (10).

20 4. An air impingement arrangement according to claim 1 and/or 2, characterized in that the air impingement in the air treatment zone of the web takes place through and/or by means of a drying wire (9) located on the web (10).

5. An air impingement arrangement according to claim 3 and/or 4, **characterized** in that the air impingement arrangement includes at least one hood (20, 20a, 20b) placed on top of a drying cylinder (23), a suction roll (28), an air impingement roll or a cooling cylinder.

5 6. An air impingement arrangement according to claim 5, **characterized** in that the air impingement arrangement is in connection with the last drying cylinder (23), suction roll (28), air impingement roll or cooling cylinder of the dryer unit (3, 5, 7), and that the air impingement arrangement comprises a hood (20) which is divided by a partition wall (27) into two sections, in which connection, in a machine direction, the web (10) is first subjected to a blowing with hot air from a hot blowing part (21) of the hood (20) and after that to a blowing with cold air from a cold blowing part (22) of the hood.

10 7. An air impingement arrangement according to claim 6, **characterized** in that the air treatment zone of the web comprises a first and a second area which are defined by the bipartite hood (20) at said hood and which extend across the width of the web (10).

15 8. An air impingement arrangement according to claim 5, **characterized** in that the air impingement arrangement comprises two successive and separate hoods (20a, 20b) placed on top of two successive drying cylinders (23), suction rolls (28), air impingement rolls or cooling cylinders, the first of the hoods being a hot blowing part (21) blowing hot air and the latter of the hoods being a cold blowing part (22) blowing cold air.

20 9. An air impingement arrangement according to claim 8, **characterized** in that the air treatment zone of the web is bipartite and comprises separately a first area which extends across the width of the web (10) and is located at the hot blowing part (21) placed first in a machine direction, and a second area which extends across the width of the web (10) and is located at the cold blowing part (22) placed after that in a machine direction.

25 10. An air impingement arrangement according to claim 8, **characterized** in that the hood (20a) located first in a machine direction is in connection with the second last drying cylinder (23), suction roll (28), air impingement roll or cooling cylinder, and that the hood

(20b) located after that in a machine direction is in connection with the last drying cylinder (23), suction roll (28), air impingement roll or cooling cylinder.

11. An air impingement arrangement according to claim 5, **characterized** in that the air impingement arrangement comprises a hood (20a) which is arranged in connection with a drying cylinder (23), suction roll, air impingement roll or cooling cylinder and which is a hot blowing part (21) blowing hot air against the web (10), and a blow box or an airborne drying unit (20b) which extends across the web and which is a cold blowing part (20b) blowing cold air against the web (10).

10 12. An air impingement arrangement according to claim 11, **characterized** in that the air treatment zone of the web is bipartite and comprises separately a first area which extends across the width of the web (10) and is located at the hood (20a) blowing hot air, and a second area which extends across the width of the web (10) and is located at the blow box or the airborne drying unit (20b) blowing cold air.

15 13. An air impingement arrangement according to claim 11, **characterized** in that the air impingement arrangement is in connection with the last drying cylinder (23), suction roll, air impingement roll or cooling cylinder of the dryer unit.

20 14. An air impingement arrangement according to any one of the preceding claims 1 to 13, **characterized** in that in order to cool the web further before it is processed further, a cooling cylinder (25) is additionally arranged to cool the web (10) in the air treatment zone or after it.

25 15. An air impingement arrangement according to any one of the preceding claims 1 to 14, **characterized** in that the temperature of air of the cold blowing part (22) is substantially lower than that of the hot blowing part (21), advantageously the temperature of air is below 50 °C in the cold blowing part (22).

16. A method for air impingement in order to compensate for the curling tendency of a paper or board web treated in connection with a paper or board process or with a related finishing process, in which air impingement method a contact-free web (10) treatment zone is formed, which treatment zone is extended to cover substantially the entire width of the web, in which paper, board and/or finishing process the web is dried in at least one dryer unit (3, 5, 7), which comprises one or preferably several downwardly open single-wire draw groups, and in which paper, board and/or finishing process, optionally, in the dryer unit and/or after it, the web is subjected to an operation or operations which is/are selected from a group which includes reeling, calendering (4), intermediate calendering, coating (6), and additional drying (5, 7), **characterized** in that, in at least one web (10) treatment zone, the web is subjected to impingement blowing with air, in which connection the web (10) is first subjected to at least one hot air blowing and after that to at least one cold air blowing.

15 17. An air impingement method according to claim 16, **characterized** in that moisture is condensed and/or absorbed into the web (10) by means of cold blowing, whereby the curl behaviour of the web is changed to the range of structural, i.e. reversible curl behaviour.

20 18. An air impingement method according to claim 16 and/or 17, **characterized** in that the air impingement in the web treatment zone is directed directly at the free surface of the web (9).

25 19. An air impingement method according to claim 16 and/or 17, **characterized** in that cold blowing is directed at the web from above the web (10) by means of and/or through a drying wire.

30 20. An air impingement method according to claim 18 and/or 19, **characterized** in that at least one hood (20, 20a, 20b) is used for air impingement, which hood is placed on top of a drying cylinder (23), a suction roll (28), an air impingement roll or a cooling cylinder and by means of which, in a machine direction, a blowing with hot air is first blown against the web (10) from a hot blowing part (21) and after that a blowing with cold air

from a cold blowing part (22), said drying cylinder (23), suction roll (28), air impingement roll or cooling cylinder being disposed in connection with the last drying cylinder (23), suction roll (28), air impingement roll or cooling cylinder of the dryer unit (3, 5, 7) and divided into two sections by means of a partition wall (27).

5

21. An air impingement method according to claim 18 and/or 19, **characterized** in that two separate hoods (20a, 20b) are used for air impingement, said hoods being placed on top of two successive drying cylinders (23), suction rolls (28), air impingement rolls or cooling cylinders disposed as the last cylinders/rolls in the dryer unit (3, 5, 7), hot air being blown through the hood (20a) which is placed first in a machine direction and which is a hot blowing part (21) blowing hot air and located in connection with the second last drying cylinder (23), suction roll (28), air impingement roll or cooling cylinder, and cold air being blown through the hood (20b) which is placed further down in a machine direction and which is a cold blowing part (22) blowing cold air and located in connection with the last drying cylinder (23), suction roll (28), air impingement roll or cooling cylinder.

10

15 22. An air impingement method according to claim 18 and/or 19, **characterized** in that for air impingement are used a hood (20a) arranged on top of and in connection with the last drying cylinder (23), suction roll, air impingement roll or cooling cylinder of the dryer unit (3, 5, 7), said hood being a hot blowing part (21) blowing hot air against the web (10), and a blow box or an airborne drying unit (20b) which extends across the width of the web and which is a cold blowing part (20b) blowing cold air against the web (10).

15

20 23. An air impingement method according to any one of the preceding claims 16 to 22, **characterized** in that the web (10) is further cooled during air impingement or after it by means of a cooling cylinder (25).

25

24. An air impingement method according to any one of the preceding claims 16 to 23, **characterized** in that the temperature of air is kept substantially lower in the cold blowing part (22) than in the hot blowing part (21), advantageously below 50 °C.

100 500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000 6500 7000 7500 8000 8500 9000 9500 10000 10500 11000 11500 12000 12500 13000 13500 14000 14500 15000 15500 16000 16500 17000 17500 18000 18500 19000 19500 20000 20500 21000 21500 22000 22500 23000 23500 24000 24500 25000 25500 26000 26500 27000 27500 28000 28500 29000 29500 30000 30500 31000 31500 32000 32500 33000 33500 34000 34500 35000 35500 36000 36500 37000 37500 38000 38500 39000 39500 40000 40500 41000 41500 42000 42500 43000 43500 44000 44500 45000 45500 46000 46500 47000 47500 48000 48500 49000 49500 50000 50500 51000 51500 52000 52500 53000 53500 54000 54500 55000 55500 56000 56500 57000 57500 58000 58500 59000 59500 60000 60500 61000 61500 62000 62500 63000 63500 64000 64500 65000 65500 66000 66500 67000 67500 68000 68500 69000 69500 70000 70500 71000 71500 72000 72500 73000 73500 74000 74500 75000 75500 76000 76500 77000 77500 78000 78500 79000 79500 80000 80500 81000 81500 82000 82500 83000 83500 84000 84500 85000 85500 86000 86500 87000 87500 88000 88500 89000 89500 90000 90500 91000 91500 92000 92500 93000 93500 94000 94500 95000 95500 96000 96500 97000 97500 98000 98500 99000 99500 100000 100500 101000 101500 102000 102500 103000 103500 104000 104500 105000 105500 106000 106500 107000 107500 108000 108500 109000 109500 110000 110500 111000 111500 112000 112500 113000 113500 114000 114500 115000 115500 116000 116500 117000 117500 118000 118500 119000 119500 120000 120500 121000 121500 122000 122500 123000 123500 124000 124500 125000 125500 126000 126500 127000 127500 128000 128500 129000 129500 130000 130500 131000 131500 132000 132500 133000 133500 134000 134500 135000 135500 136000 136500 137000 137500 138000 138500 139000 139500 140000 140500 141000 141500 142000 142500 143000 143500 144000 144500 145000 145500 146000 146500 147000 147500 148000 148500 149000 149500 150000 150500 151000 151500 152000 152500 153000 153500 154000 154500 155000 155500 156000 156500 157000 157500 158000 158500 159000 159500 160000 160500 161000 161500 162000 162500 163000 163500 164000 164500 165000 165500 166000 166500 167000 167500 168000 168500 169000 169500 170000 170500 171000 171500 172000 172500 173000 173500 174000 174500 175000 175500 176000 176500 177000 177500 178000 178500 179000 179500 180000 180500 181000 181500 182000 182500 183000 183500 184000 184500 185000 185500 186000 186500 187000 187500 188000 188500 189000 189500 190000 190500 191000 191500 192000 192500 193000 193500 194000 194500 195000 195500 196000 196500 197000 197500 198000 198500 199000 199500 200000 200500 201000 201500 202000 202500 203000 203500 204000 204500 205000 205500 206000 206500 207000 207500 208000 208500 209000 209500 210000 210500 211000 211500 212000 212500 213000 213500 214000 214500 215000 215500 216000 216500 217000 217500 218000 218500 219000 219500 220000 220500 221000 221500 222000 222500 223000 223500 224000 224500 225000 225500 226000 226500 227000 227500 228000 228500 229000 229500 230000 230500 231000 231500 232000 232500 233000 233500 234000 234500 235000 235500 236000 236500 237000 237500 238000 238500 239000 239500 240000 240500 241000 241500 242000 242500 243000 243500 244000 244500 245000 245500 246000 246500 247000 247500 248000 248500 249000 249500 250000 250500 251000 251500 252000 252500 253000 253500 254000 254500 255000 255500 256000 256500 257000 257500 258000 258500 259000 259500 260000 260500 261000 261500 262000 262500 263000 263500 264000 264500 265000 265500 266000 266500 267000 267500 268000 268500 269000 269500 270000 270500 271000 271500 272000 272500 273000 273500 274000 274500 275000 275500 276000 276500 277000 277500 278000 278500 279000 279500 280000 280500 281000 281500 282000 282500 283000 283500 284000 284500 285000 285500 286000 286500 287000 287500 288000 288500 289000 289500 290000 290500 291000 291500 292000 292500 293000 293500 294000 294500 295000 295500 296000 296500 297000 297500 298000 298500 299000 299500 300000 300500 301000 301500 302000 302500 303000 303500 304000 304500 305000 305500 306000 306500 307000 307500 308000 308500 309000 309500 310000 310500 311000 311500 312000 312500 313000 313500 314000 314500 315000 315500 316000 316500 317000 317500 318000 318500 319000 319500 320000 320500 321000 321500 322000 322500 323000 323500 324000 324500 325000 325500 326000 326500 327000 327500 328000 328500 329000 329500 330000 330500 331000 331500 332000 332500 333000 333500 334000 334500 335000 335500 336000 336500 337000 337500 338000 338500 339000 339500 340000 340500 341000 341500 342000 342500 343000 343500 344000 344500 345000 345500 346000 346500 347000 347500 348000 348500 349000 349500 350000 350500 351000 351500 352000 352500 353000 353500 354000 354500 355000 355500 356000 356500 357000 357500 358000 358500 359000 359500 360000 360500 361000 361500 362000 362500 363000 363500 364000 364500 365000 365500 366000 366500 367000 367500 368000 368500 369000 369500 370000 370500 371000 371500 372000 372500 373000 373500 374000 374500 375000 375500 376000 376500 377000 377500 378000 378500 379000 379500 380000 380500 381000 381500 382000 382500 383000 383500 384000 384500 385000 385500 386000 386500 387000 387500 388000 388500 389000 389500 390000 390500 391000 391500 392000 392500 393000 393500 394000 394500 395000 395500 396000 396500 397000 397500 398000 398500 399000 399500 400000 400500 401000 401500 402000 402500 403000 403500 404000 404500 405000 405500 406000 406500 407000 407500 408000 408500 409000 409500 410000 410500 411000 411500 412000 412500 413000 413500 414000 414500 415000 415500 416000 416500 417000 417500 418000 418500 419000 419500 420000 420500 421000 421500 422000 422500 423000 423500 424000 424500 425000 425500 426000 426500 427000 427500 428000 428500 429000 429500 430000 430500 431000 431500 432000 432500 433000 433500 434000 434500 435000 435500 436000 436500 437000 437500 438000 438500 439000 439500 440000 440500 441000 441500 442000 442500 443000 443500 444000 444500 445000 445500 446000 446500 447000 447500 448000 448500 449000 449500 450000 450500 451000 451500 452000 452500 453000 453500 454000 454500 455000 455500 456000 456500 457000 457500 458000 458500 459000 459500 460000 460500 461000 461500 462000 462500 463000 463500 464000 464500 465000 465500 466000 466500 467000 467500 468000 468500 469000 469500 470000 470500 471000 471500 472000 472500 473000 473500 474000 474500 475000 475500 476000 476500 477000 477500 478000 478500 479000 479500 480000 480500 481000 481500 482000 482500 483000 483500 484000 484500 485000 485500 486000 486500 487000 487500 488000 488500 489000 489500 490000 490500 491000 491500 492000 492500 493000 493500 494000 494500 495000 495500 496000 496500 497000 497500 498000 498500 499000 499500 500000 500500 501000 501500 502000 502500 503000 503500 504000 504500 505000 505500 506000 506500 507000 507500 508000 508500 509000 509500 510000 510500 511000 511500 512000 512500 513000 513500 514000 514500 515000 515500 516000 516500 517000 517500 518000 518500 519000 519500 520000 520500 521000 521500 522000 522500 523000 523500 524000 524500 525000 525500 526000 526500 527000 527500 528000 528500 529000 529500 530000 530500 531000 531500 532000 532500 533000 533500 534000 534500 535000 535500 536000 536500 537000 537500 538000 538500 539000 539500 540000 540500 541000 541500 542000 542500 543000 543500 544000 544500 545000 545500 546000 546500 547000 547500 548000 548500 549000 549500 550000 550500 551000 551500 552000 552500 553000 553500 554000 554500 555000 555500 556000 556500 557000 557500 558000 558500 559000 559500 560000 560500 561000 561500 562000 562500 563000 563500 564000 564500 565000 565500 566000 566500 567000 567500 568000 568500 569000 569500 570000 570500 571000 571500 572000 572500 573000 573500 574000 574500 575000 575500 576000 576500 577000 577500 578000 578500 579000 579500 580000 580500 581000 581500 582000 582500 583000 583500 584000 584500 585000 585500 586000 586500 587000 587500 588000 588500 589000 589500 590000 590500 591000 591500 592000 592500 593000 593500 594000 594500 595000 595500 596000 596500 597000 597500 598000 598500 599000 599500 600000 600500 601000 601500 602000 602500 603000 603500 604000 604500 605000 605500 606000 606500 607000 607500 608000 608500 609000 609500 610000 610500 611000 611500 612000 612500 613000 613500 614000 614500 615000 615500 616000 616500 617000 617500 618000 618500 619000 619500 620000 620500 621000 621500 622000 622500 623000 623500 624000 624500 625000 625500 626000 626500 627000 627500 628000 628500 629000 629500 630000 630500 631000 631500 632000 632500 633000 633500 634000 634500 635000 635500 636000 636500 637000 637500 638000 638500 639000 639500 640000 640500 641000 641500 642000 642500 643000 643500 644000 644500 645000 645500 646000 646500 647000 647500 648000 648500 649000 649500 650000 650500 651000 651500 652000 652500 653000 653500 654000 654500 655000 655500 656000 656500 657000 657500 658000 658500 659000 659500 660000 660500 661000 661500 662000 662500 663000 663500 664000 664500 665000 665500 666000 666500 667000 667500 668000 668500 669000 669500 670000 670500 671000 671500 672000 672500 673000 673500 674000 674500 675000 675500 676000 676500 677000 677500 678000 678500 679000 679500 680000 680500 681000 681500 682000 682500 683000 683500 684000 684500 685000 685500 686000 686500 687000 687500 688000 688500 689000 689500 690000 690500 691000 691500 692000 692500 693000 693500 694000 694500 695000 695500 696000 696500 697000 697500 698000 698500 699000 699500 700000 700500 701000 701500 702000 702500 703000 703500 704000 704500 705000 705500 706000 706500 707000 707500 708000 708500 709000 709500 710000 710500 711000 711500 712000 712500 713000 713500 714000 714500 715000 715500 716000 716500 717000 717500 718000 718500 719000 719500 720000 720500 721000 721500 722000 722500 723000 723500 724000 724500 725000 725500 726000 726500 727000 727500 728000 728500 729000 729500 730000 730500 731000 731500 732000 732500 733000 733500 734000 734500 735000 735500 736000 736500 737000 737500 738000 738500 739000 739500 740000 740500 741000 741500 742000 742500 743000 743500 744000 744500 745000 745500 746000 746500 747000 747500 748000 748500 749000 749500 750000 750500 751000 751500 752000 752500 753000 753500 754000 754500 755000 755500 756000 756

25. A paper or board machine which includes at least a former unit (1) for a paper or board web, a press unit (2) and at least one dryer unit (3, 5, 7), in which paper or board machine, for the purpose of compensating for the curl of the web, the web (10) is subjected to at least one air impingement which, arranged in connection with a paper or board process or with a related finishing process, extends substantially across the entire width of the web (10) running in the vicinity of the air impingement and forms a contact-free web treatment zone with the web, **characterized** in that the air impingement applied to the web (10) includes, following one after the other, at least one hot blowing and at least one cold blowing with air.

10

26. A paper or board machine according to claim 25, characterized in that with the moisture which condenses and/or is absorbed into the web (10) in cold blowing, the curl behaviour of the web changes to the range of structural, i.e. reversible curl behaviour.

15

27. A paper or board machine according to claim 25 and/or 26, characterized in that the air impingement in the air treatment zone of the web is applied to the free surface of the web (10).

20

28. A paper or board machine according to claim 25 and/or 26, characterized in that the air impingement in the air treatment zone of the web is applied to a drying web (9) located on the web (10) and through and/or by means of it to the web (10).

25

29. A paper or board machine according to claim 27 and/or 28, characterized in that each air impingement arrangement includes at least one hood (20, 20a, 20b) which is placed on top of the last drying cylinder (23), suction roll, air impingement roll or cooling cylinder of the dryer unit (3, 5, 7) and divided by a partition wall (27), in which connection, in a machine direction, the web (10) is first subjected to a blowing with hot air from a hot blowing part (21) of the hood and after that to a blowing with cold air from a cold blowing part (22) of the hood.

30

30. A paper or board machine according to claim 27 and/or 28, **characterized** in that the air impingement arrangement comprises two successive and separate hoods (20a, 20b) placed on top of the last drying cylinders (23), suction rolls, air impingement rolls and/or cooling cylinders of the dryer unit (3, 5, 7), in which connection, in a machine direction, the web (10) is first subjected to a blowing with hot air from the first hood (20a) serving as a hot blowing part (21) and after that to a blowing with cold air from the second hood (20b) serving as a cold blowing part (22).

31. A paper or board machine according to claim 27 and/or 28, **characterized** in that the air impingement arrangement comprises a hood (20a) which is placed first in a machine direction on top of the last drying cylinder (23), suction roll, air impingement roll or cooling cylinder of the dryer unit (3, 5, 7) and which serves as a hot blowing part (21) and blows hot air against the web (10); and a blow box or an airborne drying unit (20b) which extends across the entire width of the web and which serves as a cold blowing part (22) and blows cold air against the web (10).

32. A paper or board machine according to any one of the preceding claims 25 to 31, **characterized** by a cooling cylinder (25) which acts on the web (10) in a machine direction during or after air impingement.

33. A paper or board machine according to any one of the preceding claims 25 to 32, **characterized** in that the temperature of air of the cold blowing part (22) is substantially lower than that of the hot blowing part (21), advantageously the air temperature in the cold blowing part (22) is below 50 °C.

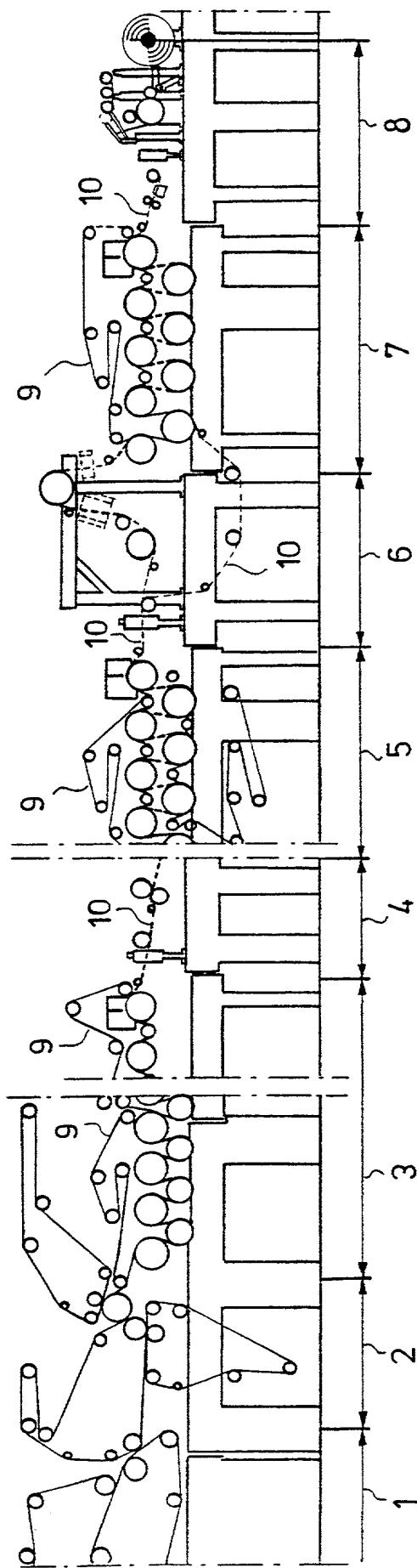


FIG. 1

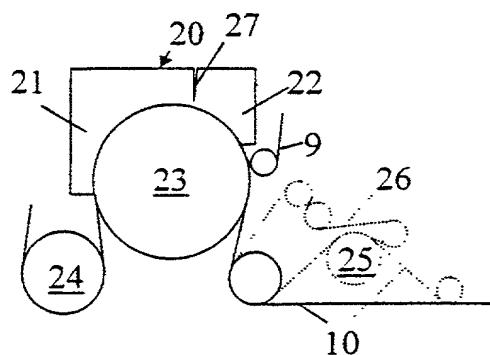


FIG.2.

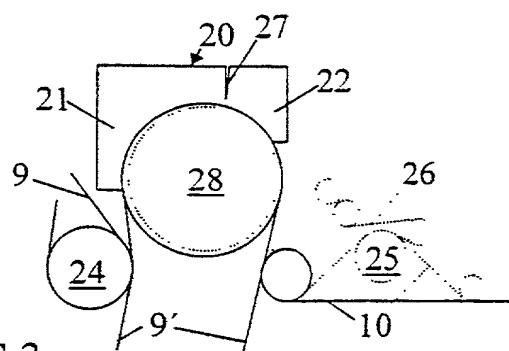


FIG.3.

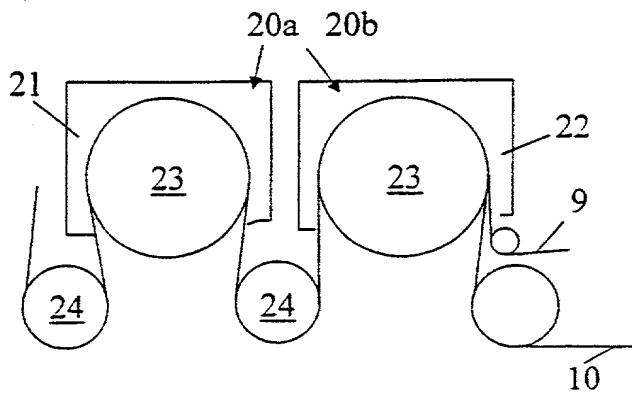


FIG.4.

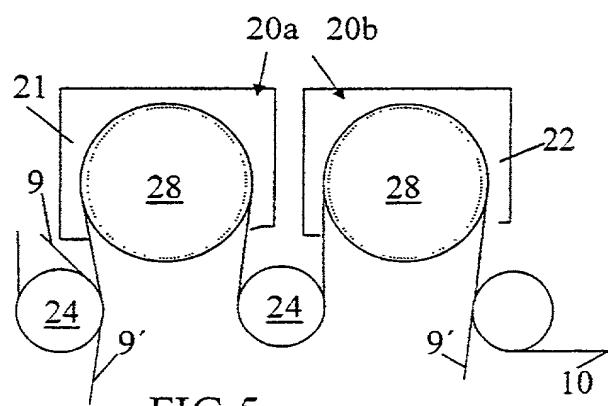


FIG.5.

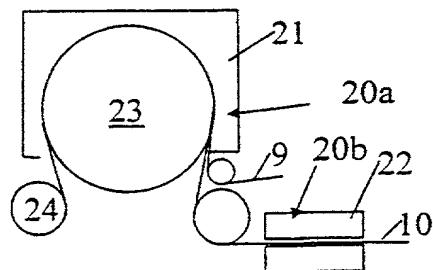


FIG.6.

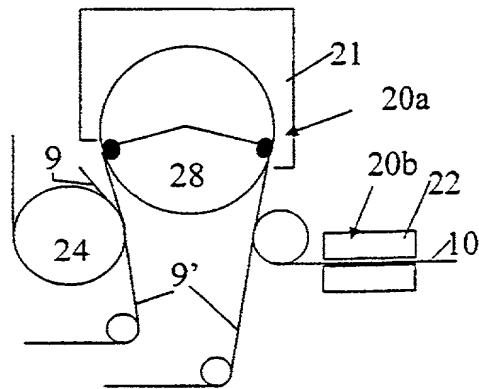


FIG.7.

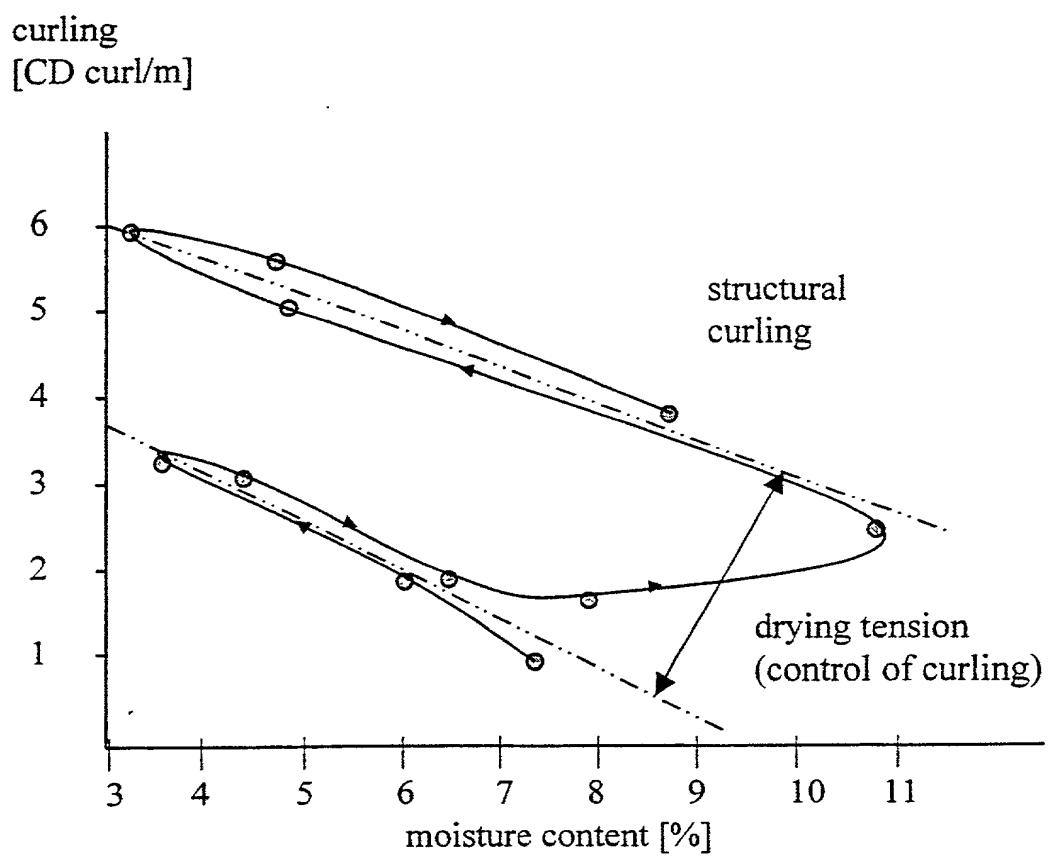


FIG.8.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

**DECLARATION FOR UTILITY OR
DESIGN
PATENT APPLICATION
(37 CFR 1.63)**

Declaration Submitted with Initial Filing

OR

Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	FORSAL-27
First Named Inventor	Pasi Ahonen
COMPLETE IF KNOWN	
Application Number	10/009,095
Filing Date	
Art Unit	
Examiner Name	

As the below named inventor, I hereby declare that:

My residence, mailing address, and citizenship are as stated below next to my name.

I believe I am the original and first inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Method and Arrangement of Impingement for Blowing Compensation of a Tendency of Curling of a Paper Board Web to be Treated as well as a Paper or Board Machine

(Title of the Invention)

the specification of which

 is attached hereto

OR

 was filed on (MM/DD/YYYY) 05/09/2000 as United States Application Number or PCT InternationalApplication Number PCT/FI00/00410 and was amended on (MM/DD/YYYY) 11/08/2001 (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent, inventor's or plant breeder's rights certificate(s), or any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	Certified Copy Attached? NO
991079	Finland	05/10/1999	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	<input checked="" type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

 Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

[Page 1 of 2]

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

DECLARATION — Utility or Design Patent Application

Direct all correspondence to: Customer Number or Bar Code Label 020,455 Correspondence address below

Name

Address

City

State

ZIP

Country

Telephone

Fax

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

NAME OF SOLE OR FIRST INVENTOR: A petition has been filed for this unsigned inventorGiven Name Pasi
(first and middle [if any])Family Name Ahonen
or SurnameInventor's Signature Date 19 Nov 2001

Jyväskylä

State

Finland

Residence: City FICountry FI
Citizenship

Mailing Address

Valimontie 69

Jyväskylä
City

State

FIN-40530

Finland
Country

NAME OF SECOND INVENTOR:

 A petition has been filed for this unsigned inventorGiven Name Harri
(first and middle [if any])Family Name Kiiskinen
or SurnameInventor's Signature Date 22 Nov 2001Jyväskylä
Residence: City FI

State

Finland
CountryFI
Citizenship

Mailing Address Hauhontie 14

Jyväskylä
City

State

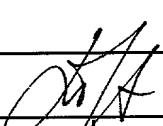
FIN-40520

Finland
Country Additional inventors are being named on the 1 supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

DECLARATION

ADDITIONAL INVENTOR(S)
Supplemental Sheet
Page 1 of 1

Name of Additional Joint Inventor, if any:		<input type="checkbox"/> A petition has been filed for this unsigned inventor	
Oleg Given Name		Timofeev Family Name or Surname	
Inventor's Signature Jyväskylä  Residence: City		Date 19.11.2001	
State		Finland Country RU Citizenship	
Helokantie 1 C A7 Mailing Address			
Mailing Address City Jyväskylä State ZIP FIN-40640 Finland Country			
Name of Additional Joint Inventor, if any:		<input type="checkbox"/> A petition has been filed for this unsigned inventor	
Given Name		Family Name or Surname	
Inventor's Signature		Date	
Residence: City		State Country Citizenship	
Mailing Address			
Mailing Address City State ZIP Country			
Name of Additional Joint Inventor, if any:		<input type="checkbox"/> A petition has been filed for this unsigned inventor	
Given Name		Family Name or Surname	
Inventor's Signature		Date	
Residence: City		State Country Citizenship	
Mailing Address			
Mailing Address City State ZIP Country			

Burden Hour Statement: This form is estimated to take 21 minutes to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.